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Convergent elaboration: Equating the mnemonic value of provided and generated words and images

Martin, Laureen Sandborg, Ph.D.

The University of North Carolina at Greensboro, 1990

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CONVERGENT ELABORATION: EQUATING THE MNEMONIC VALUE OF PROVIDED AND GENERATED WORDS AND IMAGES

by

Laureen Sandborg Martin

A Dissertation Submitted To
the Faculty of the Graduate School at
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MARTIN, LAUREEN SANDBORG, Ph.D. Convergent Elaboration: Equating the Mnemonic Value of Provided and Generated Words and Images. (1990)
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Three incidental-learning procedures tested the hypothesis that the picture superiority, imagery, and generation effects each depend on the convergence of elaboration on the target concept rather than on the extent of elaboration. Undergraduates saw pairs of either words or pictures, either interacting or adjacent, and either verbalized or imaged the relationship between the items.

It was predicted that for presented relationships, one item would become a more effective cue for the other if the orienting task directed elaboration to the relationship rather than to associations of the separate items. If the picture superiority effect reflects the constraining effect on elaboration imposed by the more explicit stimuli, this effect should be enhanced in paired-associate learning by verbalization of the relationship (Experiment 1). If the imagery effect reflects the constraining effect on elaboration of generating specific perceptual associations of generic concepts, relational phrases should benefit more than interactive pictures from visualization of the relationship (Experiment 2). In both cases, the stimulus-task combination that directed elaboration to the relationship between cue and target was expected to produce

the higher recall.

For generated relationships, no recall difference was expected between stimulus modalities (Experiments 1, 2, and 3) nor between orienting tasks (Experiment 3), since generation was hypothesized to promote maximum cue-target convergence. Since familiar pairings should also promote convergent elaboration, likely relationships were expected to be more retrievable than unlikely relationships.

All recall predictions were confirmed ($p < .05$). Recognition of individual items produced the same pattern of results as cued recall but at a higher level. That is, a task that did not promote convergence on the relationship presented was also ineffective in making the items in the relationship distinctive. Pearson correlations of recall and reported strategy, as well as of imagery vividness ratings and recall indicated that differential imaginal elaboration did not account for the memory effects.

The compatibility of the results with dual and amodal models of representation and with a processing view of semantic memory is discussed.

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CHAPTER I

INTRODUCTION: ELABORATIVE PROCESSING AND MEMORY EFFECTS

The way in which we organize and access knowledge is a topic of intense current controversy. New findings are straining the credibility of previously adequate models of semantic memory, and new models of limited applicability are multiplying to cover the deficiencies. One cause of the theoretical ferment is a barrage of recent evidence which will be considered in this chapter that elaborating verbal material with supplementary information does not necessarily increase the probability of its retrieval (e.g., Anderson, 1983, p. 199).

Apparently the traditional principle that the more associations of a word are involved in its processing, the better it will be remembered can no longer be stated in this simple, quantitative form. In fact, there is reason to believe that the true relationship between recall and the number of associations activated at encoding is an inverse function (Nelson, Bajo, & Casanueva, 1985). According to the emerging view of elaboration, only associations that specifically relate a target concept and the contextual information that will serve as a retrieval cue are likely to facilitate recall.

The research described in this thesis extends this new principle, convergent elaboration, from verbal to nonverbal processing and applies it to both externally provided and internally generated information. The hypothesis tested in the research is that regardless of the stimulus mode through which a concept is acquired, regardless of whether the context for its interpretation is a part of the stimulus or is generated from prior knowledge, and regardless of whether the product of contextual elaboration is verbal or imaginal, effective processing involves not more but more cogent associations--the associations that will be relevant during a retrieval attempt.

Chapter I develops the convergent elaboration hypothesis by analyzing the correspondences among three reliable memory effects. Two of these effects, the advantage of pictures over words and of imaginal over verbal orienting tasks, are generally thought to exemplify the benefits of more extensive elaboration. The third effect, better memory for internally generated words than for externally provided ones, has been explained in several ways. Even though some of these explanations assume that more associations are involved in generating words than in reading or hearing the words of others, most agree that subjective generation results in a more distinctive trace--a qualitative view of memory enhancement.

The fact that this view is inconsistent with the quantitative account of elaboration offered for the mnemonic advantage of pictorial stimuli or an imaginal task has not been explored, probably because the investigation of verbal effects and of nonverbal effects has largely been the province of competing models of representation. Yet a comparison of the conditions that produce consistent memory effects in either paradigm suggests that it is more restricted, not more extensive, elaboration that enhances retrieval in every case.

Chapter II describes three experiments comparing the mnemonic effectiveness of provided and generated words and images. These experiments demonstrate that the usual advantage of pictures, of imagery, and of generation can each be eliminated by manipulations affecting the quality of elaboration. Their results support the conclusion that there is no intrinsic difference in mnemonic value between stimulus modes providing differing amounts of perceptual detail nor between experimenter-provided and subject-generated elaboration. Nor does it seem to matter whether the elaboration is induced verbally or visually. The only variable found to predict relative recall consistently was the mutual specificity of retrieval cue and target concept.

Chapter III discusses the implications of convergent elaboration for the nature of semantic representation. In

developing a unified explanation of effects usually separately assigned to either modality-dependent or amodal storage, it suggests a way of reconciling the two models.

Elaborative Processing

Extensive Elaboration

Both common sense and personal experience confirm the usefulness to memory of making new experiences as richly meaningful as possible, of elaborating them with old knowledge; it is a truism of popular wisdom as well as instructional practice. Until recently, the assumption of a causal relationship between the amount of semantic elaboration and the probability of retention has permeated cognitive psychology as well, and many of its theorists are still disposed to treat this relationship as a phenomenon to be explained rather than as an hypothesis to be tested.

A frequent explanation of the advantage of semantic elaboration has been that it increases the number of associations involved in the processing of a concept and that this increase in associative involvement increases the number of routes by which the concept may later be accessed (e.g., Anderson & Reder, 1979; Craik & Tulving, 1975). That is, even while demonstrating the fallacy of the once widely accepted principle that all learning is a positive function of such quantitative external events as

repetition, rehearsal, and reinforcement, cognitive psychology has tended to endorse an equally quantitative account of internal events.

Even theorists who differ on the question of whether associative representation is amodal and abstract or involves separate systems for verbal and nonverbal storage have concurred on the value of more extensive elaboration. For example, advocates of bimodal storage propose two quantitative explanations for the greater memorability of concrete than of abstract words: (1) concepts with distinct perceptual referents are represented in a spatial mode, a form naturally more associatively complex than a sequentially organized verbal representation, and (2) whereas both concrete and abstract concepts have verbal representation, concrete concepts are more likely to be represented in the spatial mode as well (Paivio, 1971, p. 220). Paivio, whose dual coding theory has been the most influential version of this modality-based account of representation, hypothesizes that both the picture-superiority effect--better memory for the picture of a concept than for its label--and the imagery effect--better memory for a word when a particular referent is considered--demonstrate that accessing a word's nonverbal representation during encoding increases its later availability by promoting redundant storage (Paivio, 1971,

pp. 179, 391; 1986).

The elaboration stressed by amodal accounts of semantic memory differs from that of bimodal accounts in positing entirely abstract knowledge structures; it tends to be equally quantitative. Although Anderson himself documented the sometimes detrimental effect on memory of elaboration, refering to this effect as "irrelevant fan" (e.g., Anderson, 1983, p. 199), his network model has contributed to the popular equation of the spread of activation with its effectiveness. He, too, has at times seemed to equate the value of elaboration with its quantity, as in his unqualified statements that "memory for a piece of information can be improved by manipulations that increase the amount of elaboration performed," "elaborations facilitate recall by providing additional retrieval paths" (1980, p. 192), and "the most critical determinant of retention is the number of elaborations" (Anderson & Reder, 1979, p. 390).

The influence of this view of elaboration is apparent among other well known proponents of amodal processing. Craik and Tulving (1975), for example, attributed the improved noun recall they obtained with an increase in the complexity of sentence contexts to the amount of associative elaboration the noun concepts received, which they assumed to be greater when the contextual information

provided was richer. Greater elaboration was also invoked by Lockhart, Craik, and Jacoby (1976) as the reason that less familiar or more complex text was better recalled than was easier material.

This quantitative hypothesis remains strong in much recent discussion of memory effects. Eysenck (1979) applied it to word lists, arguing that the recall advantage for lists consisting of semantically related items results from an increase in the elaboration of encoding. McDaniel (1984) applied it to stories, attributing the superior recall of idea units composed of words with missing letters to increased total elaboration. The assumption that more is better often emerges even when the reference to elaboration is not explicit. For example, Kolers (1975) cited "extensiveness of processing" to explain the improved memorability of sentences presented in an inverted orientation, and "amount of processing" was offered by Johnson-Laird, Gibbs, and de Mowbray (1978) as a sufficient reason for the higher recall of words that were positive instances in a category judgment task.

With such a variety of findings showing an advantage for associatively elaborated over nonelaborated concepts, it was heuristically useful to attribute the advantage to elaboration per se. Regardless of their position on the representation of verbal and nonverbal knowledge, many

cognitive psychologists considered the higher recall of the more concrete or more conceptually related items, as well as of items that were evaluated more thoroughly and those that were comprehended less readily, to be evidence of the advantage of associative embellishment. Lately, however, some findings have emerged which require a reassessment of the link between elaborating and remembering.

Convergent Elaboration

In 1972, Craik and Lockhart proposed that the retention of verbal material depends on the "depth" of processing, with semantic elaboration preferable to equally extensive processing focused on such superficial aspects of words as their phonology and spelling. Although considered a qualitative alternative to the view that retention depends on the extent of elaborative rehearsal, the depth-of-processing hypothesis was also quantitative in its assumption that each "level" of encoding corresponds to an absolute mnemonic value, without reference to retrieval goals. Nevertheless, the idea that it is the kind of processing that matters, not its amount, stimulated a great deal of research on verbal memory effects, and while disconfirming encoding depth as an explanation (Eysenck, 1979; Hunt & Mitchell, 1978; Stein, 1978), some of the findings that emerged challenged quantitative accounts of memory effects in general.

A number of investigators observed a positive correlation between memory and the difficulty of the orienting task (e.g., Kolers, 1975; Tyler, Hertel, McCallum, & Ellis, 1979), a result seeming to justify the equating of elaboration and distinctiveness. Others, however, found no such correlation. In fact, when the processing actually allocated to a task was measured by a decrement in the performance of a concurrent task, the items processed more extensively (or intensively) often proved to be no more memorable than those encoded more automatically (Mitchell & Hunt, 1989).

Jacoby and Craik's (1979) demonstration that memory is enhanced by both a more difficult encoding task and a retrieval situation that is more relevant to that task was another step away from an absolutist, quantitative view of the benefits of elaboration. When the recall of target words was cued by words with which they had been associated by a relational decision, the result was higher recall than recognition scores. Jacoby and Craik concluded that memory for an item depends on its discriminability from other items at retrieval rather on the extent to which it was elaborated or the semantic depth to which it was processed.

A resolution of the confusion about elaboration and memory was proposed by Stein, who reasoned that the processing evoked by contextual information--that is,

automatic elaborative processing--can promote recall of a target term only to the extent that it clarifies the significance of this term (Stein, 1978; Stein & Bransford, 1979; Stein, Morris, & Bransford, 1978). In other words, it might be the precision with which a concept was defined, not the extent to which it was embellished, that determined its retrievability.

This premise implies that semantic elaboration may reduce as well as facilitate recall. Stein supported his argument with a number of demonstrations that contextual information is useful only if it clarifies the relationship between a target word and the concept that will later serve as its retrieval cue. He found that unless specifically relevant to the target, information that increases the complexity or distinctiveness of its context is relatively ineffective in promoting recall. Recall of the word tall was no better when it was presented in an elaborated sentence, "The tall man purchased the crackers that were on sale," than in its base form, "The tall man purchased the crackers." Elaboration served retrieval of the target only when it was relevant to tallness: "The tall man purchased the crackers that were on the top shelf." (Stein & Bransford, 1979; Stein, Brock, Ballard, & Vye, 1987; Stein, Littlefield, Bransford, & Persampieri, 1984; Stein, Morris, & Bransford, 1978)

As formulated by Stein, the principle of precise elaboration pertains exclusively to verbal material. Its relevance to nonverbal contextual elaboration or to nonverbal or verbal generated elaboration is unclear. Nevertheless, the demonstration of the importance of the precision of descriptive elaboration for the recall of coherent language suggests that convergent processing may be crucial for the retrieval of other everyday experiences.

Two steps are involved in extending the concept of convergence from words to nonverbal stimuli and from verbal to nonverbal processing. The first is to specify the conditions under which elaboration converges on a target response. A theoretical justification is needed for the counterintuitive claim that less associative processing occurs in viewing pictures, imagining objects, or generating words than in simply comprehending isolated words. The remainder of the chapter is devoted to this analysis. The second step is empirical--to support the hypothesis that regardless of whether stimulus modality or orienting task imposes the constraint during encoding, its influence on the retrieval process is the same. This support is provided in Chapter II.

Memory Effects

Among the uncertainties of memory research, three effects are predictable in a variety of processing conditions. Study after study supports the conclusions that (1) pictures are more memorable than words, (2) words are more memorable when their referents are imagined, and (3) one's own words are more memorable than those of others. Since picture superiority and imagery effects are generally attributed specifically to visual processing, they have been studied primarily by proponents of dual representation. The third effect, the generation effect, although not a necessary consequence of amodal representation, has been of interest primarily to proponents of propositional models or to those who were not committed to a particular model of long-term memory.

Dual-coding theory, despite its emphasis on the value of image production, does not predict a general advantage for subjective generation (i.e., Paivio, 1986). The propositional models, despite their concern with the associative organization of memory, have given little empirical attention to the probability that the greater part of knowledge concerns visually acquired spatial associations. As a result, quite different paradigms have been used in studying the three effects, and the relationship between generating and imaging remains

unresolved. There are nevertheless similarities across paradigms in the conditions that enhance or depress retrieval. These similarities become more evident when the effects are characterized in terms of processing rather than of stimuli or tasks.

The Picture Superiority Effect

The typical manifestation of the picture superiority effect occurs in studies comparing memory for object concepts presented either as pictures as as nouns (e.g., Jenkins, Neale, & Deno, 1967; Madigan, McCabe, & Itatani, 1972; Paivio & Csapo, 1973; Paivio & Yarmey, 1966; Sampson, 1970). The basic observation that only pictures provide explicit information about the physical features of objects may suggest that this perceptual information is directly registered in an imaginal form. Thus the picture superiority effect is customarily assumed to be the result of the differential access of pictorial and verbal stimuli to imaginal processing. According to dual coding, it is also more likely that a picture will evoke a label than that a noun will evoke an image, and therefore the picture is more likely than the word to be registered in two forms (Paivio, 1971, p. 179; Paivio, Rogers, & Smythe, 1968).

The same observation, however, could as validly lead to the speculation that it is the specificity with which an item is defined in an associative system that determines

its memorability. A generic label might promote elaboration that is extensive and imprecise, whereas the perceptual information provided by a picture might constrain and direct elaboration, resulting in more definite traces. Even when supposedly conveying a generic concept, a picture might restrict processing to a subset of potential associations of the concept; a single word, even a subordinate term, would impose no comparable restrictions.

Studies comparing pictures and one-word labels thus confound stimulus mode and information value. Even the undistinguished outline drawings commonly used in learning studies convey a context for the object depicted, the features that individualize it. A word, however, is only a feature of the verbal or perceptual context in which it occurs and is itself defined by this context. A decontextualized word could therefore evoke only relatively diffuse associative processing. In general, the more contexts in which it was habitually used, the less the processing it evoked should converge on a pattern exclusively associated with a particular interpretation. So without a defining context to direct processing, word comprehension would be only approximate, and the attenuated traces of this processing would be relatively ineffective in directing retrieval.

But if it is the specificity of the information conveyed by pictures and not the perceivability of this information that accounts for the picture superiority effect, then verbally presented information that defined an item as specifically as does a picture should promote equivalent recall. This speculation would suggest that either a picture advantage or a word advantage might be obtained by manipulations that affected the specificity with which elaboration converged on a relationship between the cue and target items.

In fact, although the well documented ascending sequence of mnemonic effectiveness from abstract nouns to concrete nouns to pictures to physical objects (Paivio, 1971) suggests that for any two sets of stimuli, the more concrete will be the more readily learned, this formula does not always work. When items must be retained in the order of presentation, concrete nouns may be recalled no better than abstract nouns (Brener, 1940) and pictures may be recalled no better than their concrete labels (Paivio & Csapo, 1969; Paivio, Yuille, & Rogers, 1969). Apparently, knowledge of the perceptual features of particular items is irrelevant to this learning task. In other words, when retrieval depends on relational knowledge, such as the order of successive items, elaboration directed to item-specific information may be misdirected.

But even when retrieval does depend on knowledge about particular items, explicit perceptual information may not be helpful. If memorability were simply a function of concreteness, one would expect realistic, detailed pictures to be more comprehensible and memorable than more stylized representations. Yet diagrammatic drawings can be better thán accurate illustrations for teaching complex concepts (Alesandrini, 1984). The pictures used to demonstrate the picture superiority effect are often quite abstract outline drawings. Such stimuli typically produce a ceiling effect in recognition and verbal recall (Kobayashi, 1985), so apparently they are not less effective than more concrete materials such as photographs or three-dimensional objects.

Furthermore, if the mnemonic superiority of pictures results from the elaborative processing they promote, then the more aspects of a picture are considered, the more memorable it should become. Yet adults who had judged photographs of faces on such traits as dependability (judgments presumably requiring attention to multiple features) recognized the faces no better than did others who had judged them on the presence of a single distinctive feature (Winograd, 1981). The functional equivalence of the two judgment tasks implies that the same principle may have operated in both conditions. That is, pictures may be

well remembered because their sensory richness promotes focused, distinctive elaboration, or, in Winograd's words, "the chances of a unique encoding increase as one encodes more features" (p. 185).

These observations suggest that the presentation of information in a pictorial form facilitates learning not because this information is concrete but because it is usually salient to a target concept. They also suggest that the picture superiority effect is only a shifting point on a continuum of memory effects that exemplify the value of appropriately directed processing and that have little to do with concreteness per se.

The Imagery Effect

Words are better recalled if subjects are advised to form a visual image of the named object than if they are either told to rehearse the words or given no strategy instructions (e.g., Paivio & Yuille, 1969). This well established effect has been widely accepted as prima facie evidence for the dual coding hypothesis that the image of a verbal referent is stored in a form distinct from the verbal code, providing an alternative route to the concept and doubling the probability of its retrieval. The troublesome issue that is not resolved by this explanation is the validity of the comparisons by which the imagery effect is demonstrated. In the standard comparison of

verbal and imaginal orienting tasks, just as in the comparison of pictures and their one-word labels, information value is a confounding factor.

In demonstrating an imagery effect, processing directed toward the perceptual features of a particular instance of a concept is compared with the undirected processing of a generic concept. Without an attempt to instantiate the generic term through imagery, the associations it evokes may be inchoate, disorganized, and inconsistent. There may or may not be more elaborative involvement in imagining an instance of an object concept than in considering its meaning in relation to other concepts, but the knowledge accessed with the former strategy is certainly more specific. The relative ineffectiveness of the processing with which intentional image formation is usually compared may therefore be due to its imprecision and not to its verbal nature. If so, then verbal elaboration that is comparable to imaginal elaboration in its specificity should promote comparable memory.

An entirely unequivocal test of this possibility may not be feasible, since any verbal elaboration that made an item more specific would probably disambiguate its appearance and so intensify the conscious experience of imagery. However, the role of appropriate elaboration

might be approached indirectly by demonstrating that the mnemonic value of imagery instructions varies as a function of the degree to which the imaginal task integrates cue and target items as a relational concept.

The proponents of dual coding attribute the improved probability of recalling a word when its referent is purposefully imagined to the superiority of two codes over one. Nevertheless, another dual-coding tenet, that the comprehension of a concrete word usually involves the spontaneous activation of an image, although with a lag of a second or more (Paivio, 1971, p. 76), suggests that a conscious strategy of image formation is either redundant or futile, depending on the time available. Along with its corollary, that recognition of a pictured object involves the spontaneous and immediate activation of its label, this tenet implies that the value of either generated or provided images results not from the dual coding they engender, since this duality is automatic, but from the **quality** of processing entailed by perceptual-imaginal **elaboration**.

It does not follow, however, that memory for pictures as well as for words would be improved by imaginal elaboration. A pictorial symbol may, as dual coding theory claims, tend to activate a predictable generic label. Even so, the processing of perceptual information specific to

the instance depicted may conflict with the accessing of dominant associations of the label that are not apparent in the picture. Therefore the attempt to elaborate the concept imaginally, which would depend on the strong convergence of this concurrent activation on subjective associations, might fail. Therefore pictures may be inferior to words as stimuli for intentional imagery.

One significant step toward dissociating imagery and conceptual specificity has been made in the study of the mnemonic advantage of concrete to abstract words, an effect dual-coding theorists consider a clear manifestation of the advantage of spontaneous imaginal elaboration (e.g., Paivio, 1971, p. 85). The context-availability hypothesis explains the concreteness advantage as the result of a preference for using concrete terms in most ordinary circumstances, making a context for interpretation more available in associative memory for concrete than for abstract words (Johnson, Bransford, Nyberg, & Cleary, 1972; Kieras, 1978; Schwanenflugel & Shoben, 1983; Wattenmaker & Shoben, 1987). By turning the focus in the concreteness effect from the "visibility" of dominant associations to their semantic relevance, the context-availability hypothesis not only offers a testable alternative to the dual-coding account of memory for verbal stimuli but also suggests the amenability of other imagery-related phenomena

to amodal analysis.

A context-availability resolution accords with the analysis of memory effects proposed in this paper insofar as it rejects imagery as an explanation and considers differential retrieval in terms of the integration of polysemous words in an associatively organized system. However, it differs from the view of elaboration that is proposed here in defining the availability of a particular context in terms of the number of contexts potentially available. One problem with the context-availability equation of memorability and variety of meanings is that it fails to explain an undisputed correlate of concreteness--reported imagery value (e.g., Paivio, 1971, p. 79). If a greater number of contexts for interpretation causes the concreteness effect, one would hardly expect the more concrete words to evoke the more vivid images, a phenomenon which seems to indicate the dominance of a specific interpretation. It would seem more valid to conclude that a single context becomes more available as concepts become more concrete because there are fewer competing contexts.

The Generation Effect

A typical generation paradigm compares memory for words that have been wholly or partially self-generated in response to verbal associations with memory for the same words when they have been explicitly presented. The usual

finding is that a word is more memorable if it was self-generated than if it was read or heard (e.g., McFarland, Frey, & Rhodes, 1980; Slamecka & Graf, 1978).

The generation effect seems particularly compatible with a propositional network model of representation, since with a semantically organized system, a word that comes to mind in response to a relational rule and a specific word cue is of necessity already linked to that cue. It is unlikely that the linkage would be as close with an externally provided word. Therefore a generated response would be more likely than a provided response to be reaccessed during a retrieval attempt prompted by the original encoding cue (Slamecka & Fevreiski, 1983; Slamecka & Graf, 1978).

In contrast to effects which clearly involve imagery, the generation effect does not necessarily suggest the operation of differential semantic elaboration. Yet quantitative principles have frequently been invoked to explain the effect. Some researchers have explicitly equated the generation effect with the extent of elaborative processing (e.g., Craik and Tulving, 1975; Johnson-Laird et al., 1978; Kolers, 1975). Other proposals--number of operations (McFarland, Frey, & Rhodes, 1980), cognitive effort (Tyler et al., 1979), semantic depth (Jacoby, 1978)--implicitly base the effect in the

extent of lexical involvement.

However, the consensus seems to be that generating a word produces a more distinctive encoding than does reading it (e.g, Jacoby, 1978; Jacoby, Craik, & Begg, 1979; Schmidt, 1987). Although the process by which distinctiveness is achieved remains vague, it clearly pertains to the quality, not the quantity, of processing. Some suggestions are that a generated term profits from its integration with prior knowledge and that generation increases the strength of the cue-response or context-item relationship--interpretations consistent with the idea of convergent elaboration (Graf, 1980; Greenwald & Johnson, 1989; Nairne & Widner, 1987; Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Rabinowitz & Craik, 1986).

When situations which do not produce a generation effect are considered, the convergence explanation of retrieval failure is clearly applicable. Whether or not there is a mnemonic advantage for material that a subject has helped to produce seems to depend on two factors: the semantic relationship of the generated to the provided material and the relevance of this relationship at the time of recall. The generation effect occurs for meaningful but not for meaningless nonwords and for familiar but not unfamiliar or infrequent nouns pairs (Gardiner and Hampton, 1985; McElroy & Slamecka, 1982; Nairne, Pusen, & Widner,

1985). Furthermore, the superiority of generated to read words is manifested only when recall is cued by the stimulus words or when stimulus-response word pairs are to be recognized, not in tests of free recall or recognition of only the response words (Graf, 1980). Considered together, these findings indicate that generation does not exert its effect on the response term alone but on the semantic relationship between this term and the stimulus which evoked it during both the initial generation and the later regeneration. In other words, subjective generation may well promote recall by promoting the convergence of semantic processing on the cue-target relationship.

This explanation is supported by Stein and Bransford's (1979) demonstration that the mnemonic efficacy of generated elaboration depends on its relevance to the target concept. Subjects who produced continuations of base sentences about a man described with various target adjectives showed enhanced recall of the adjective when cued by their own elaborated sentence frame only if the continuation clarified the significance of this attribute. Those who produced continuations that simply made the situation more specific recalled less than subjects for whom target-relevant continuations had been provided, even though the generated elaborations were undeniably personally relevant.

Organization Effects

The superiority of semantically related stimuli to the same stimuli presented as unrelated items is ubiquitous in memory research. It occurs in comparisions between associated and nonassociated pairs of words, between coherent sentences and randomly combined words, between paragraphs with sentences in a logical sequence and paragraphs with sentences randomly ordered, etc.

The proponents of dual coding theory attribute these effects to the cohesion that a stored compound image provides between discrete verbal elements (Begg, 1983; Bower, 1970). A cohesive image may be constructed as a deliberate strategy to link unrelated items; it may also be spontaneously evoked by semantically related items. Paired-associate learning is better if subjects are advised to form an image of the two items in interaction than if they are told only to form images of them (Bower, 1970). Furthermore, a cohesive image may be perceptually provided: pictured objects are more memorable if depicted as interacting than if shown side by side (Epstein, Rock, & Zuckerman, 1960).

Like dual coding theory, the propositional models explain the power of relational processing in terms of the cohesion it establishes between otherwise separate elements, but they describe this cohesion as conceptual,

not imaginal. According to a propositional account, relating concepts in a comprehensible way improves the odds of their being recalled as a unit by strengthening their linkage in an associatively organized system (Anderson, 1983).

The ubiquity of organization effects suggests a unifying principle behind the perceptual and verbal memory effects under consideration: relational processing improves memory by unifying the component concepts--that is, by restricting their meaning to the associations consistent with the relational concept. Organization effects may thus be considered general manifestations of the reductive form of elaboration hypothesized to underlie each of the effects considered in this paper. The elaboration provided by pictures is more definitive than the elaboration evoked by labels, and the elaboration that is intentionally generated, whether verbalized or imaged, is more definitive than the elaboration that is externally provided. In other words, elaboration that converges on a coherent relationship seems to be more effective than more inclusive or more arbitrary elaboration.

Promoting Convergence Through Generated Elaboration

Imagery as Generation

Most of the demonstrations that have been described as generation effects have dealt with verbal stimuli and verbal production only. The assumption behind this restriction on research has seemed to be that since the activation of nonverbal knowledge is not directly observable, it does not qualify as generation. Nevertheless, the benefits of generation have been shown not to depend on overt responding. Slamecka and Fevreiski (1983) have demonstrated a retrieval advantage, relative to words that were read, for the same words when they were sought during a generation attempt but not produced or even consciously accessed. Thus the unobservability of imaginal processing should not exempt it from consideration as generation.

The widely held idea that thinking which produces images is analogous to visual perceptions, involving the parallel processing of spatially organized associations, whereas thinking that produces words involves strictly serial associative processes, might be considered a major deterrent to the equating of visual and verbal generation. A promising answer to this objection has been proposed by

Marschark, Richman, Yuille, and Hunt (1987), who point out the necessity of distinguishing between on-line, modality-specific processes and the organized knowledge that is output by, and input to, these processes. More than one product might be constructed from amodal knowledge configurations, just as the same palette may be used to create an impressionistic landscape or a formal geometric composition, depending on the intentions of the artist. Furthermore, the distinction between parallel and serial processes is far from clear, since they apparently occur simultaneously during all semantic processing and seem to indicate only relative hemispheric tendencies rather than distinct processing modalities (Marschark & Surian, 1989).

Other findings suggest more directly that the mnemonic effects of generating images and of generating words reflect a single function. The visual task analogous to remembering experimenter-provided text is remembering experimenter-provided pictures. Yet despite the supposed power of the picture superiority effect, the intentional generation of images can make reading a better learning method than viewing pictures (Rasco, Tennyson, & Boutwell, 1975). It therefore seems resonable to attribute the imagery effect not to the pictorial qualities of images but to the process of generating them.

To describe imagery as a form of generation is not to explain its mnemonic benefits. In fact, simply indicating the similarity of verbal and nonverbal effects does not advance the understanding of either form of generation. Nor does it explain the relationship between the constructive imagery evoked by words and the retained images of visual perceptions. To integrate these seemingly disparate external and internal events in an orderly system, some factor common to the processing of each is needed. This commonality is convergent elaboration.

Convergent Elaboration Predictions

The reasoning outlined in the preceding pages implies that memory depends on the convergence of elaboration during the initial encoding and again during a retrieval attempt. The convergence of the activation that occurs in response to an initiating event on specific associations would determine the conceptual integration of the event. In the case of words, the fewer the dominant meanings, the more concentrated would be the activation and the stronger its traces. In the case of pictures, the more specific the depiction to the target concept, the more likely would activation be to converge on the target label.

During cued recall (and it can be argued that retrieval is always cued, externally or internally), activation which occurs in response to an element of the

original event would converge to some degree on the previous pattern. That is, the effectiveness of a cue would depend on the extent to which it had previously been exclusively associated with the target. The convergent elaboration of cue and target might result from their mutual salience in numerous past experiences (semantic convergence) or it might occur during a single cogent experience (episodic convergence). Recognition memory could be considered a special case of cued recall, one in which the retrieval cue is especially apt to reactivate the target traces.

Although this account assumes automatic spreading activation, it does not suppose that all meanings of a word are equipotential. An interpretation might be temporarily primed by an externally or internally established associative bias, or a more stable hierarchy of probable meanings might direct processing in the absence of an explicit context. If the dominant associations of a word were visual, activation might converge on an instantiation, experienced as a visual image.

The picture superiority effect is also explicable in terms of convergent elaboration. A picture of a concept would induce very constrained processing because of its distinctive perceptual features. By contrast, a verbal label for the concept could have many possible

instantiations and would activate a corresponding breadth of associations. So unless a defining context were either provided or generated, the processing it induced would be diffuse and therefore unmemorable.

If the foregoing analysis is valid, the three effects under consideration all indicate the advantage of convergent elaboration. Accordingly, it should be possible, either by imposing more constraint on elaboration in the normally inferior condition, or by inducing irrelevant elaboration in the normally superior condition, to nullify this advantage. Furthermore, it should not matter whether the elaboration is evoked by objective stimulus features, as in the Stein and the Nelson studies, or by subjective intentions. With the appropriate biasing of elaborative processing, pairwise comparisons of conditions that usually indicate an absolute superiority for pictures, imagery, or generation should reveal the relativity of these effects.

The three experiments reported in Chapter II ask whether the picture superiority effect can be eliminated through verbal generation and whether imaginal and verbal generation can be equally effective in promoting retrieval. The thesis proposed in this paper--that picture and imagery effects depend on the relative convergence of processing on the relationship between a potential cue and target--

suggests the cases in which these effects should be vulnerable. These cases would compare the mnemonic effectiveness of experimenter-provided and subject-generated relational elaboration. In general, the following processing conditions should affect associative activation and memory performance in the following ways:

(1) In a comparison of stimulus modes with a task directing attention to the cue-target relationship, the mode providing the more explicit information on the relationship should promote the more convergent elaboration, producing a picture superiority effect (Experiment 1).

(2) In a comparison of stimulus modes with a task not directing attention to the cue-target relationship, the mode requiring the more explicit subjective elaboration should promote the more convergent elaboration, eliminating the picture superiority effect (Experiment 2).

(3) In a comparison of orienting tasks, the task requiring subjective elaboration of a cue-target relationship not explicit in the stimuli should promote the more convergent elaboration, producing imagery or generation effects (Experiments 1 and 2).

(4) In a comparison of stimuli, the form combining the more dominant cue-target associations should promote the more convergent elaboration, producing a familiarity

effect (Experiments 1, 2, and 3).

(5) In a comparison of forms of elaboration hypothesized to have comparable effects on convergence, apparent picture superiority and generation effects should be reduced or eliminated (Experiment 3).

A convergence account would also welcome evidence that the relevance to memory of an imaginal strategy depends jointly on task demands and stimulus characteristics--i.e., the finding that more (or less) imagery is reported with an imaginal than with a verbal task, or that vividness ratings are higher (or lower) with pictures than with words, but that these differences do not necessarily correlate with recall. Such findings would help to confirm the nonfunctional nature of the imagery experience.

CHAPTER II

EXPERIMENTS: EQUATING THE MNEMONIC VALUE OF WORDS AND PICTURES THROUGH GENERATED ELABORATION

Three experiments were performed to consider the interaction of stimulus mode (verbal or pictorial) and processing orientation (verbal or imaginal) in determining the effectiveness of retrieval cues. Recall was compared with predictions based on an advantage for more extensive semantic elaboration and with predictions based on an advantage for elaboration that converged on the relationship between the target concept and the recall cue.

One potential result of these comparisons would have supported the dual-coding premise of an advantage for pictures that are labeled or words that are imaged. Another result would have suggested that imagery also accounts for the generation effect. Either of these outcomes would have confirmed the value of more extensive elaboration of the stimuli. The pattern of results that occurred suggests that this quantitative account is incorrect and that pictorial presentation, deliberate imagery, and verbal generation are simply alternative means of increasing the precision with which elaboration converges on a target response.

Experiment 1: Equating the Mnemonic Value of Words and Pictures Through Generated Verbal Elaboration

The first experiment asked two questions. The first was whether promoting convergent elaboration by means of a verbal task could make words as memorable as pictures--that is, could appropriate elaboration eliminate the picture superiority effect? The second question was whether promoting convergent elaboration by means of a verbal task could make provided information as memorable as generated information--that is, could appropriate elaboration eliminate the generation effect?

An incidental learning procedure was used to focus attention on the orienting task. The task was to construct and produce, by speaking into a tape recorder, a sentence in which two objects are related by a preposition. The objects were shown as either pictures or their labels, and the prepositional relationship was either provided by the stimuli or generated by the subject. Since the efficacy of either element of a pair in later cuing the other depends on the establishment of a concept that relates them, this procedure allows the mnemonic value of verbally generated concepts and verbally or pictorially provided concepts to be compared.

Experiment 1 Predictions

The principles of extensive elaboration and convergent elaboration imply two distinct patterns of recall (see Table 1). As explained in the sections which follow, a more precise ordering of recall scores might have been predicted on the basis of these principles. However, the two-value (high vs. low) patterns shown are sufficient to differentiate the hypotheses tested and have the advantage of being more consistent, more conservative, and far more clear than a four-value set of predictions.

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
Extensive Elaboration	High	Low	High	Low
Convergent Elaboration	High	Low	High	High

Table 1. Extensive elaboration and convergent elaboration recall predictions for pictures and words in provided and generated relationships with verbal orienting task.

Extensive Elaboration Predictions

Since pictures are more informative than words, they are customarily assumed to be processed more extensively than the corresponding verbal labels. It is appropriate to invoke Paivio's dual coding theory in considering the

relative elaboration of words and picture pairs, since it is acknowledged to be the most complete model of the processes underlying the picture superiority effect. Nevertheless, it should be understood that some of the comparisons made in this study--e.g., between the Pictures, Provided, and the Pictures, Generated, conditions--have not been addressed by dual coding and that therefore some of the predictions made in this experiment and those that follow are extrapolations from the theory and not explicit aspects of it.

According to dual coding theory, pictures are directly registered in an imaginal form, whereas the imaginal coding of words is indirect and less certain. Assuming that the task of putting a complex concept into words would be particularly apt to discourage this indirect imaginal coding, it is reasonable to expect a lower incidence of dual coding with words than with pictures. It is also consistent with the theory that the dual-coding advantage for pictures should occur whether or not the relationship to be verbalized is explicitly provided; two pictures should be more conducive than two nouns to the formation of an interactive image because they convey specific information about the constituent objects. Therefore, as indicated in Table 1, the extensive elaboration predictions are consistent with a picture superiority effect for both interactive and separate stimuli.

Strategy usage should corroborate this outcome: not only should more reliance on imagery be reported in the picture than in the word conditions but a positive correlation between recall and imagery usage should occur in all conditions.

The dual coding tenet that the memorability of a concept is determined by the number of modalities participating in its processing permits the prediction of relative retrieval only within each source-of-relationship condition. It does not permit the prediction of any specific interaction between stimulus modality and degree of subjective generation. Whatever the effect of verbal generation--if it improved the recall of pictures and words to the same extent, if it benefited pictures more than words, or if it benefited words more than pictures--dual coding could attribute the effect to an enhancement of either mediational-imaginal or verbal-associative processing.

To do so, however, it would have to argue that such processing was less likely or less effective in one case than in the other. Since dual coding considers pictures intrinsically imageable, words should be the primary beneficiaries of generated mediational imagery. Therefore, if a generation effect occurred for words, a higher correlation between reported imagery and recall might be

expected for words in the generated than in the provided condition. The corollary of this outcome might be predicted if a generation effect occurred for pictures: Even though a sentence-production task ensures verbal processing of the object names and their relationship in all conditions, pictures should be particularly apt to benefit from an increase in verbal elaboration due to generation of the relationship. Therefore a higher correlation between reported verbal processing and recall might be expected for pictures in the generated than in the provided condition.

Convergent Elaboration Predictions

As a comparison of the patterns in Table 1 reveals, each replicates that of the other mnemonic principle in three of the four stimulus conditions. A convergent elaboration pattern is distinguished from an extensive elaboration pattern only by the prediction of high recall in the Words, Generated, condition. That is, only one low-recall condition was predicted on the basis of the convergence of elaboration. In comparison with the unsuitability of the provided phrases together with the sentence-production task for promoting convergent elaboration, the other stimulus-task combinations seemed relatively suitable.

Presumably, associations of both constituent concepts are implicated in the processing of a relationship between

them. Subjective orientation as well as stimulus features influence this processing, and either factor may direct processing to associations that specify the relationship. In the Words, Provided, condition neither factor provides this constraint. A noun-preposition-noun phrase conveys minimal information about the interaction between two objects, whereas a great deal of knowledge about the objects as separate entities and in other relationships is latent in memory. The orienting task of Experiment 1 requires only that the syntactic role of the three words be replicated in a prescribed sentence frame. Thus, even though the phrase expresses a relational concept, there is no impetus, external or internal, for the semantic elaboration of relational particulars--perceptual, functional, or situational. It was therefore predicted that the Words, Provided, condition would not promote convergence on relational associations, so that the power of either label to later access the relational concept would be weak.

One means of directing the automatic elaboration of each object concept to associations specific to their relationship would be to generate this relationship. When a relationship which must be verbalized is not provided, the associations of both objects that are compatible with a permissible relationship would have to be processed more

intensively than are features of the objects that are irrelevant to an interaction between them because it is only on the basis of this subset of associations that a choice of prepositions could be made. The traces of this convergent elaboration, reactivated when either component occurred as a cue, would facilitate retrieval of the other. It was thought that the facilitation might be stronger for two nouns than for two pictures because the pictures would impose perceptual elaboration irrelevant to that involved in generating a relational concept. If so, the two word conditions would produce the extreme scores on the recall scale: highest when the relationship was generated, lowest when it was provided. With the simple line drawings used in this study, however, it seemed as likely that the divergent influence of any irrelevant perceptual detail would be offset by the relational specificity imposed by the verbal task, so that pictures would be nearly as effective as words as stimuli for generation. Therefore moderately high recall was predicted for the Pictures, Generated, condition.

Convergence of elaboration ranked the two picture conditions indeterminate in their relation to each other. Although only two stimulus conditions involve the conceptual generation of a relationship, verbalizing the relationship conveyed by a picture should focus processing on the relational concept in the same way as would

generation of the concept and should have the same effect on memory. There seemed no reason, therefore, to expect a generation effect for pictures. The only other clear expectation about the pictorial stimuli was that the specificity of either separate or interactive pictures would constrain processing more than would the nonspecificity of three-word phrases--i.e., a picture superiority effect was predicted for the provided relationships.

Another implication of a convergence view of associative activation is that one element of a pair is more apt to be an effective cue for the other when the relationship between them is familiar than when it is arbitrary. Functional and perceptual associations formed in a single episode might not be cohesive enough to override competing associations to the cue. However, an episode that evoked an already established relational concept should strengthen associations between the cue and that concept. Therefore a second prediction of elaborative convergence was that familiar relationships should be better recalled than unfamiliar relationships. Because of the long association of mnemonic imagery and bizarreness, and because more generation presumably occurs in expressing a novel concept than in expressing a familiar one, this predicted familiarity effect is not necessitated by either

an imagery or a generation account.

One final prediction of elaborative convergence was that the expected pattern of recall would not occur in recognition. Cued recall depends on the elaboration of a concept relating cue and target; recognition depends on elaboration of just the target concept. Since this concept was both provided and named in all conditions, it was thought that it should be recognized equally well in all conditions. This prediction does not differentiate the three processing principles, since it is not inconsistent with the mnemonic value of either imagery or verbal generation. However, it is confirmatory only for a convergence view, since high recognition in a condition that produced low cued recall would indicate that the low recall was not attributable to incomplete processing of the target itself but to incomplete convergence of this processing on those associations of the target that relate it to the cue. Equivalent recognition between stimulus conditions would also confirm that the necessity of producing a label in cued recall did not penalize those for whom the original presentation had been pictorial.

Summary of Experiment 1 Predictions

Cue-target pairs were shown in one of four stimulus conditions: as concrete nouns, either adjacent or connected by an interactive preposition, or as pictures, either adjacent or interactive. The orienting task was the

same in all conditions, to verbalize a (or the) relationship between the items in a complete sentence.

Because of the hypothesis that cued recall depends on the joint efficacy of stimulus and task in promoting the convergence of elaboration on the cue-target relationship, the pattern of results was expected to disconfirm predictions based on an absolute advantage for either pictorial stimuli or verbal generation. Contrary to the picture superiority effect, high recall was predicted for words as well as for pictures when a relationship between cue and target items was generated; contrary to the generation effect, high recall was predicted for pictures in provided as well as in generated relationships. The convergence principle also implied that recall would be higher for likely than for unlikely relationships in all conditions. A further prediction was that reported strategy usage would not support an imagery-effect interpretation of the results.

Experiment 1 Method

Design

There were five factors of two levels each: Source of Relationship (Provided or Generated), Stimulus Mode (Pictures or Words), List, and Gender were between-subjects factors; Likelihood of Relationship (Likely or Unlikely) was a within-subjects factor. The eight between-subjects

conditions were factorially combined: 40 subjects saw picture pairs and 40 saw word pairs; the relationship between each pair was presented to 20 subjects in each Stimulus Mode condition and generated by 20; 10 subjects in each of these cells saw a stimulus set completely different from that shown to the other 10; and women and men were equally represented in every cell.

Subjects

Eighty students of introductory psychology received course credit for their participation. Five men and five women were arbitrarily assigned to each condition. All participants were right-handed. (Preliminary scaling of the stimuli had been done the previous semester by 108 undergraduates from the same course.)

Materials

Stimuli. In a preliminary study, 42 pairs of concrete nouns linked by the preposition "in" or "on" had been rated on a seven-point scale for "the likelihood of the occurrence of the relationship." The likely and unlikely pairs derived from these ratings were each divided into two sets equated on mean likelihood, then the four sets were combined to produce two lists consisting of ten likely and ten unlikely pairings. The remaining two pairs, plus two unrated pairs, were designated as training stimuli.

Four versions of each list were constructed: separate pictures, separate words, interactive pictures, and

interactive words. It should be noted that even in the likely set the two objects were not highly associated. For example, the relationships "thermos in vest" and "kitten on package" were among those rated most likely. (A copy of the likelihood rating form is shown in Appendix A. Lists 1 and 2, with the mean likelihood rating of each prepositional relationship, are shown in Appendix B.)

The pictures, black-and-white line drawings of common objects, were taken from the Peabody Picture Vocabulary Test booklet (Dunn, 1959). The picture pairs were arranged either in a comprehensible interaction (a lamp on the back of a turtle) or in the same orientation as in the interactive set but side by side (a lamp beside a turtle). The corresponding word pairs, printed in lower-case letters, were separated either by the preposition "in" or "on," depending on the corresponding picture (lamp on turtle), or by a dash (lamp -- turtle).

The eight stimulus sets were videotaped for presentation on a 16x25-inch screen. The thickness and sharpness of the lines were comparable for verbal and pictorial stimuli, and their overall dimensions were approximately the same. (Examples of separate and interactive pictures and words are shown in Appendix C.)

Strategy report form. The strategy report form was designed to assess the extent to which, regardless of the

instructions they received and their intention to comply with them, subjects were aware of using imagery during the sentence-production task. The sheet containing eight strategy statements pertaining to possible combinations of imaginal, verbal, and relational processing--e.g., "I visualized each of the two objects" (imaginal); "I thought of the names of the two objects" (verbal); "I visualized the interaction between the objects" (imaginal-relational). A copy of the strategy report form, along with the instructions given on its use, is shown in Appendix F.)

Cued-recall forms. The items presented on the left of the screen (the agents of the relationship) served as cues for recall of the items presented on the right (the objects of the relationship). These 20 cues were presented as a list of either words or pictures, according to the acquisition mode. Although the list order was randomized, the cues to Likely and Unlikely relationships appeared in separate columns to facilitate scoring. All subjects in each Mode-List condition were given the same form. (Appendix G contains copies of the four cued-recall forms.)

Recognition forms. In addition to the 20 target words (the objects of the relationship) for the relevant list, the recognition form contained the 20 targets from the other list plus 40 nouns semantically related to the targets. (Appendix H shows the recognition form.)

Procedure

The students were tested individually, seated at a table facing a video monitor and a tape recorder 6 ft away.

Instructions. Participants were told that the study concerned the effect that speaking might have on the ability to think about things that are easy to name. The task was the same in all conditions--to wait until the stimulus pair disappeared from the screen, then to describe aloud a relationship between the objects in a sentence of the form "The X is in/on the Y. (A sign reminding the student of this sentence frame was posted at eye level below the video monitor.) In the Provided conditions this relationship was apparent in the phrase or picture presented. In the Generated conditions, the item shown on the left was always the agent of the relationship, but the preposition was chosen by the speaker. (Instructions for the Provided and Generated conditions of Experiment 1, with variations in wording for the two Stimulus Mode conditions, are in Appendix D.)

Training. Four training stimuli were shown while the subject practiced producing appropriate sentences. These stimuli consisted of two familiar and two unfamiliar pairings and, in the Relationship-Provided conditions, of both "in" and "on" relationships. The same training sets were used in both List conditions. In order to accustom the subject to the time constraints of the procedure, the

four trials were presented without interruption. After giving the subject any further instructions or encouragement required, the experimenter started the tape recorder, dimmed the lights, left the room, and used a remote-control switch to start the presentation.

Acquisition. The stimuli occurred at a 12-sec rate: a stimulus pair remained on the screen for 4 sec; then the screen was blank but illuminated for 6 sec, during which time the subject stated the relationship between the items in six words, using the sentence frame "The (name of the item on the left) is (in/on) the (name of the item on the right)." A row of asterisks appeared across the screen for 2 sec before the onset of the next stimulus pair. There were several reasons for this rather deliberate rate: (1) to encourage relaxed, "natural" processing, (2) to promote elaboration of the stimuli in terms of the response options, and (3) to obviate any tendancy to respond while the stimuli were still visible, thereby ensuring that remembering was necessary to perform the sentence-production task, even in the case of Words, Provided, which would otherwise have been essentially a reading-aloud condition, and (4) to provide ample time for completion of the spoken sentence (the correctness of which was the ostensible variable of interest).

Although the overt performance was equivalent for everyone, for half the subjects the relationship they described was provided. Half of these subjects saw noun-preposition-noun phrases, the others saw the corresponding interactive pictures. The other subjects saw either the noun or the picture pairs side-by-side and decided on the preposition. So those who saw the phrase "kitten on package" would produce the same sentence as those who saw the picture of a striped kitten sitting on a gift-wrapped package: "The kitten is on the package." Those who saw either the two nouns or the two pictures side-by-side might say either "The kitten is on the package" or "The kitten is in the package."

Strategy reporting. After stopping the videotape and turning off the tape recorder, the experimenter told the student that the real purpose of the study was to compare the kinds of thinking that occurred with various kinds of stimuli. In order to forestall any experimenter demand effect, the experimenter emphasized that any, or any combination, of the thought processes described might have occurred during the preceding task that none was more effective than another. Passive terms were used in referring to the conscious experience to indicate that the process was not considered under the control of the individual. It was also stressed that the study was concerned with differences among groups, not individuals.

After this explanation, the student was given a form for reporting the strategies used in the sentence-production task, (These instructions, plus a copy of the strategy report form, are in Appendix F.)

The student was told to write a number from 0 to 100 before each of the eight statements on the form to report the percentage of the time this form of thinking had occurred--i.e, the sum of the numbers had to be 100. To encourage the serious engagement of each participant in this introspective exercise, the experimenter urged him or her to take as much time as necessary. To avoid disrupting the student's concentration (since the testing room was small), the experimenter remained out of the room while he or she was doing the strategy-reporting task (as well as during the subsequent retrieval tests). After 5 min, the experimenter returned to ask the student to check that the percentages totaled 100. After 2 min more, the experimenter again returned and removed the strategy form. All participants completed the form within 7 min.

Retention testing. Immediately after completing the strategy report, the student was surprised with a cued recall test. The time between the acquisition and recall stages of the procedure was approximately 11 min. The cues for recall of the other member of each pair were the agents of the relationship, a list of either pictures or words,

according to the original presentation mode. The experimenter told the subject that he or she would have five minutes to write after every cue the name of the object with which it had been associated in the first task, guessing if necessary, then left the room.

After 5 min the experimenter returned briefly to again urge that a noun be written after each item on the list, asking that two more minutes be devoted to remembering these objects. After 2 min the cued-recall form was removed and the 80-word recognition test was given.

The student was told that the names of all 20 of the objects he or she had been trying to remember were on the list and was asked to check just these 20 words. The experimenter again left the room, returning after 5 min to remind the student to count the checkmarks to be certain there were exactly 20 and offering more time for the task, if necessary. Nobody needed more than 7 min to complete the recognition test. After removing the recognition form, the experimenter explained the purpose of the research and ended the session by obtaining the participant's agreement not to discuss the procedure with other students.

Scoring

In this and subsequent experiments, a second scorer blind to predictions verified the experimenter's recall, recognition, and strategy scoring. The two scorers resolved the few discrepancies that were found by mutual

agreement. Occasionally, the name by which a subject had referred to a pictured object differed from the corresponding word stimulus. For example, the "package" was sometimes called a "present" or a "box." In such cases, the name used by the subject was considered the correct response on the cued-recall form. These low-frequency responses did not seem to impair performance on the recognition test. Almost invariably, the designated target response was chosen by those who had produced a synonymous term at acquisition.

Experiment 1 Results

Retention

The alpha level for rejection of the null hypothesis was .05 in this and in the other experiments reported. Preliminary ANOVA's on the recall, recognition, and strategy scores of subjects in each of the 32 cells revealed no differences due to Gender nor to List, so these data are pooled in the reported results.

Cued recall. For every between-group F ratio, MS_e (1,76) = 485.9. Although an over-all picture advantage (Pictures, 66.1%; Words, 50.1%) produced a decided effect for Stimulus Mode (F = 21.1), and although a generation advantage (Provided, 46.0%; Generated, 70.3%) produced an even more potent effect for Source of Relationship (F = 48.4), the result that makes these standard results

comprehensible is the Mode x Source interaction (F = 47.4).

As Table 2 shows, the source of this interaction was the inferior recall of noun pairs in predetermined relationships (inferior to all other combinations by 40 percentage points). The significance of this disparity, as well as of other deviations from the effects predicted by imagery and generation principles, was confirmed by one-tailed, a priori t tests. Although the usual picture superiority effect occurred when relationships were Provided [Pictures, 66.0%; Words, 26.0%; t (18) = 5.7], words were at least as effective as pictures when relationships were Generated (Pictures, 66.2%; Words, 74.2%). Although the usual generation effect occurred with Words (Provided, 26.0%; Generated, 74.2%; t = 6.9), verbal generation provided no advantage for Pictures (Provided, 66.0%; Generated, 66.2%). In other words, recall was high for targets related to their cues by a generated preposition, regardless of the stimulus mode, and for targets presented as pictures, regardless of the source of the relationship, in accordance with the convergence predictions in Table 1.

The within-subject factor Likelihood of Relationship (Likely, 63.8%; Unlikely, 52.5%) had a strong influence [F (1,76) = 26.7, MSe = 189.8], and Likelihood did not interact with Stimulus Mode or Source of Relationship. However, the recall advantage for the more plausible

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(20)	(20)	(20)	(20)
CUED RECALL:	66	26	66	74
Likely	70	30	76	80
Unlikely	62	23	57	69
RECOGNITION:	92	69	92	92
Likely	92	70	93	94
Unlikely	92	67	90	91

Table 2. Percentage recall and recognition of pictures and words in provided and generated likely and unlikely relationships with verbal orienting task (Exp. 1).

relationships was even greater when the relationship was Generated [Likely, 77.8%; Unlikely, 62.8%; $\underline{t}$ (38) = 3.04] than when it was Provided (Likely, 49.8%; Unlikely, 42.3%). As the breakdown of scores in Table 2 shows, this facilitation was especially evident when pictures were the stimuli for generation. For Pictures, Generated, the likelihood effect appeared as a difference of 18.5 percentage points [Likely, 75.5%; Unlikely, 57.0%; $\underline{t}$ (18) = 3.00]; for Words, Generated, the difference was 11.5

percentage points (Likely, 80.0%; Unlikely, 68.5%; t = 1.87).

Recognition. The recognition results essentially replicated the recall pattern, although at a higher level. For every recognition F ratio, MSe (1,76) = 176.0. Even though the recognition list consisted of words only, the advantage for processing based on pictorial stimuli was maintained. Stimulus Mode produced a decided main effect (Pictures, 91.5%; Words, 80.4%; F = 28.1). The effect of Source of Relationship was equally evident (Provided, 80.0%; Generated, 91.9%; F = 32.0). The Mode x Source interaction was also maintained (F = 32.0), and as can be seen in Table 2, it was again the Words, Provided, condition which produced the outlying data. Only 68.5% of the nouns originally presented in phrases were recognized, 23 percentage points lower than the mean scores for the other conditions [t (18) = 5.5], which clustered in the narrow range of 91.5% to 92.3%.

Besides increasing the general level of performance from 58.1% to 85.9% (F = 375.8, MSe = 82.3), the recognition results differed from those of cued recall in one clear way: they showed no advantage for Likely over Unlikely relationships. As the breakdown of recognition scores in Table 2 shows, the familiarity of the context in which the targets had been processed did not affect the

ability to recognize them.

Reported Strategies

Table 3 shows the reported usage of eight possible strategies. As the distribution and general smallness of these percentages suggest, the students were not in agreement on the best description of their thought processes in any stimulus condition. Nevertheless, certain tendencies emerged. In the high-recall, Generated conditions, the only strategies that received scores above 20% were the Imaginal-Relational (I-R) mixed strategy (Pictures, 26.0%; Words, 39.3%) and the Imaginal-Verbal-Relational (I-V-R) combination (Pictures, 23.1%; Words, 25.3%). In the equally high-recall Pictures, Provided, condition, the high-scoring strategies were Verbal (V), 26.3%; Verbal-Relational (V-R), 21.4%; and I-V-R, 20.8%. There was even less agreement among students in the low-recall Words, Provided, condition, in which the top ratings were given to V, 19.6%; I-R, 16.2%; Imaginal (I), 15.8%; and Imaginal-Verbal (I-V), 14.2%.

Although these data seem to present a serious problem for the contention that the picture superiority and generation effects obtained depend on imagery, the value of imagery, or of any conscious strategy, cannot be discounted without consideration of the correlation between its usage and recall. Table 3 also shows these correlations (Pearson's r coefficients). With df = 18, the critical

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(20)	(20)	(20)	(20)
CUED RECALL:	66	26	66	74
IMAGINAL:				
% Usage	4	16	12	17
Usage-Recall r	.31	.19	-.05	.12
IMAGINAL-RELATIONAL:				
% Usage	10	16	26	39
Usage-Recall r	.06	.50**	-.39*	-.21
VERBAL:				
% Usage	26	20	14	1
Usage-Recall r	.01	-.31	-.30	-.04
VERBAL-RELATIONAL:				
% Usage	21	10	9	2
Usage-Recall r	-.03	-.04	.18	.02
IMAGINAL-VERBAL:				
% Usage	16	14	8	12
Usage-Recall r	.17	-.27	.14	.05
IMAGINAL-VERBAL-RELATIONAL:				
% Usage	21	10	23	25
Usage-Recall r	-.24	.16	.20	.06
RELATIONAL:				
% Usage	1	12	6	1
Usage-Recall r	.02	.04	.01	.01
NONE:				
% Usage	8	2	2	2
Usage-Recall r	.02	-.43*	.20	.14

Table 3. Percentage reported usage of eight strategies with verbal orienting task, and correlation of strategy usage with recall (Exp. 1)

* = $p < .05$; ** = $p < .01$

value for the planned one-tailed test of positive correlation is .378; however, since some negative correlations were as strong as the positive ones, the two-tailed critical value of .444 might be considered appropriate. The correlation between I and recall was nonsignificant in all conditions by either criterion. In fact, the only significant positive correlation (.495) occurred for IR with Words, Provided, in which only 16% usage of this strategy was reported, suggesting that if interactive imagery had been used, it would have helped.

Because the participants surely differed not only in their retrospective assessment of conscious experience but in their interpretation of the strategy statements, requiring them to make judgments about eight separate strategies may have increased the within-condition variability and obscured underlying between-condition similarities or differences. In order to clarify any such underlying regularities, each subject's percentages were re-scored in terms of three basic strategies: Imaginal, Verbal, and Relational (I, V, and R). Of the eight strategies described on the strategy report form (Appendix F), four involve imagery (1, 2, 5, and 6), four involve implicit verbalization (3, 4, 5, and 6), and four involve relational processing (2, 4, 6, and 8). Thus if more than one version of a basic strategy were reported, the sum of a subject's scores might exceed 100. For

example, the strategies of a subject who reported 50% for statement 1 ("I visualized each of the two objects"), 25% for statement 2 ("I visualized the interaction between the objects"), and 25% for statement 3 ("I thought of the names of the two objects) would receive the following scores: I, 75%; V, 25%; R, 25%.

The mean percentages shown in Table 4 therefore indicate relative, not exclusive, reliance on each of the three basic strategies. Although the numeric overlap in percentage usage among these strategies precludes their being statistically compared, it is valid to compare the usage of a given strategy for each stimulus condition. The within-groups error term for the following t tests is MSe (2,152) = 891.9.

The highest incidence of I (94.0%) was reported by the Words, Generated, subjects, significantly higher [t (18) = 5.7] than that of the Words, Provided, subjects (56.1%). The Pictures, Generated, subjects also reported significantly more I (69.3%) than did the Words, Provided, subjects (t = 2.0). These values thus suggest an overall correspondence between imagery and generation [I, Provided, 53.5%; I, Generated, 81.6%; t (38) = 4.5]. They do not reflect performance on either memory test, which showed a generation effect for Words only.

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(20)	(20)	(20)	(20)
CUED RECALL:	66	26	66	74
IMAGINAL STRATEGY:				
% Usage	51	56	69	94
Usage-Recall r	.01	.26	.04	.07
VERBAL STRATEGY:				
% Usage	83	54	55	41
Usage-Recall r	-.17	-.33	.19	.08
RELATIONAL STRATEGY:				
% Usage	52	48	64	67
Usage-Recall r	-.36	.34	.10	-.18

Table 4. Percentage reported usage of three basic strategies for pictures and words in provided and generated relationships with verbal orienting task, and correlation of strategy usage with recall (Exp. 1).

A connection between imagery and retrieval is even less apparent in the other percentages in Table 4. Despite equally high levels of recall in the two Generated groups, they reported quite different I [Pictures, Generated,

69.3%; Words, Generated, 94.0%; *t* (18) = 3.7). Furthermore, the Pictures, Provided, subjects, for whom recall was high, reported no more *I* (50.6%) than did the Words, Provided, subjects (56.1%), for whom recall was abysmal.

Pearson tests of correlation between strategy scores and recall confirmed the inadequacy of an imagery-based account of the effects obtained. As indicated in Table 4, *I* Usage-Recall correlations were nil in all three high-recall conditions and weak (*r* = .256) in the Words, Provided, condition.

The most reliance on *V* was reported by the Pictures, Provided, subjects (83.0%), significantly higher [*t* (18) = 4.3] than that of the unfortunate Words, Provided, subjects (54.2%). However, the latter percentage was no lower than the *V* reported in either of the high-recall Generation conditions (Pictures, 54.6%; Words, 40.5%). In fact, less *V* was reported with verbal stimuli when verbal generation was required than when all key words were provided (Words, Provided, 54.2%; Words, Generated, 40.5%; *t* = 2.1).

In any case, the low or negative *V* Usage-Recall correlations shown in Table 4 indicate that verbalization did not benefit memory for either pictures or words. The only strategy usage pattern that even approximated the pattern of recall occurred for *R*. Except with relational phrases, however, even *R* did not predict recall. The *R*

Usage-Recall correlation for Words, Provided (.341) was the strongest positive correlation in the data, and the only one that approached significance.

Discussion of Experiment 1

Memory

Subjects were required to state relationships between pairs of objects for which perceptual information did or did not appear and for which the relationships were or were not specified. Later, a surprise test of recall of one member of the pair was cued by the other. The main question of interest was whether the pattern of recall would be more consistent with the hypothesized advantage for convergent elaboration or with one of the alternative views considered. Figure 1 summarizes the recall data presented in Table 2 and provides graphic reminders of the type of stimuli that produced these data.

If the mnemonic value of an event depends on the amount of detail specified by the stimulus, pictures should have produced better retrieval than their labels. This result occurred when the stimuli provided a relationship but not when a relationship between the two items was generated. If the generation of elaboration is more important than elaboration per se, better retrieval should have occurred when a mediator between the items was generated than when it was provided. This result occurred

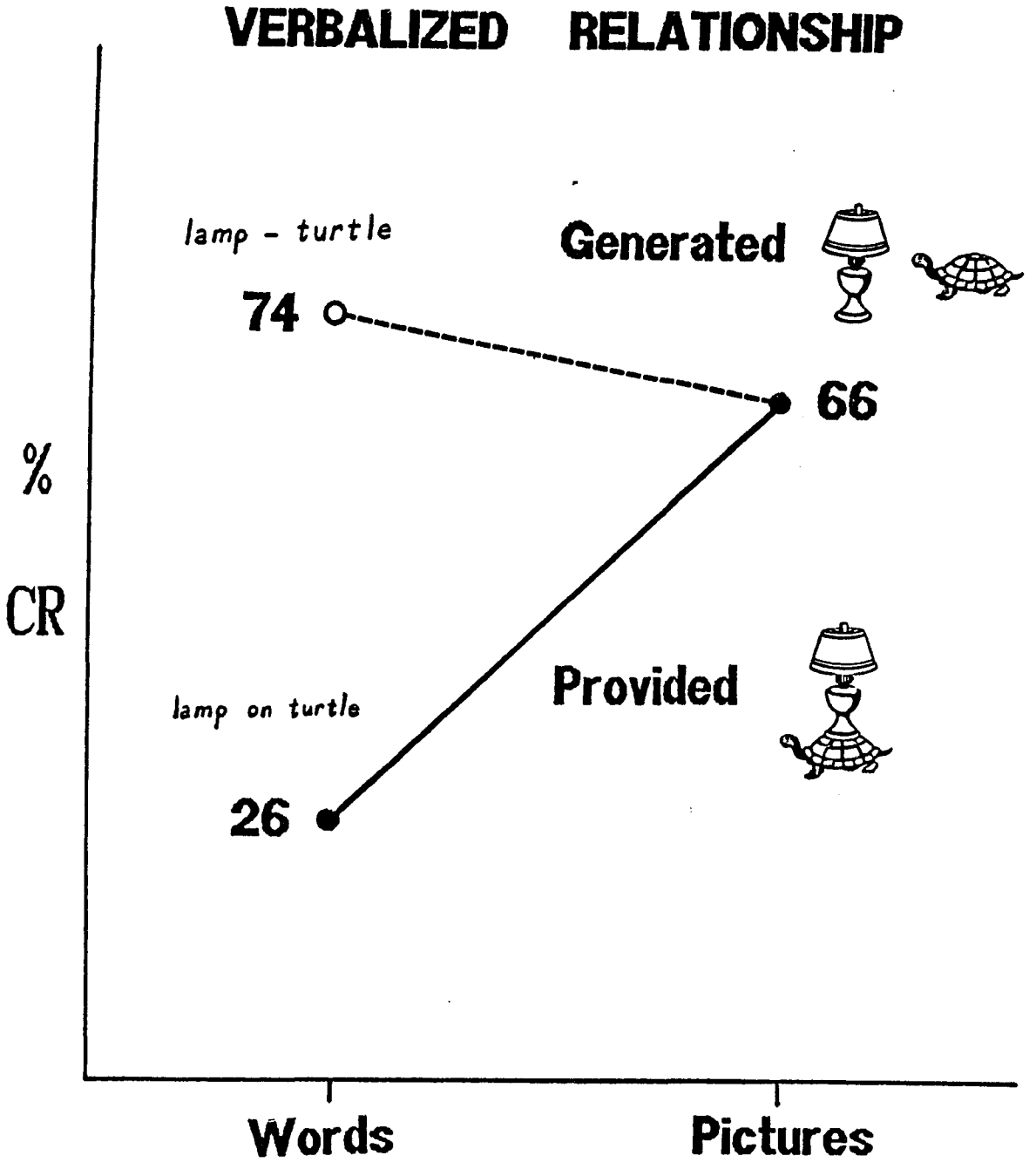

Figure 1. Percentage recall of pictures and words in provided and generated relationships with verbal orienting task (Exp. 1).

for words but not for pictures. As a comparison of the results in Table 2 (or Figure 1) with the predictions in Table 1 reveals, the pattern of recall obtained is consistent with convergent elaboration.

A second issue addressed by Experiment 1 was the mnemonic value of plausibility. Better recall for items in likely relationships would be compatible with any associative model of representation, including dual coding. However, only a convergence account of processing requires a "likelihood effect" in cued recall because the processing of established associations is necessarily more convergent than is the processing of novel provided ones. Although the likely pairs did have a recall advantage in all conditions, the advantage was significant only for generated relationships. Apparently the disadvantage for unlikely pairs was greater when a relationship between the items was generated than when it was provided, perhaps because the search for a conceivable relationship is wider when few associations are shared by cue and target than when more associations overlap, whereas associative strength has less influence on elaboration when it is driven by a provided relationship.

Since the associative overlap between cue and target items is maximal when the retrieval cues are the targets themselves, elaborative convergence predicted no difference

between likely and unlikely relationships with a recognition test. This prediction was also confirmed.

Despite the confirmation of elaborative convergence predictions by the over-all pattern of cued recall, the interpretation of this pattern is complicated by the unexpectedly low recognition scores for nouns which had occurred in phrases. Although poor recognition in a condition that produced poor cued recall is not inconsistent with a convergence model, it could indicate that the reason for the poor recall was not just insufficient relational convergence but insufficient elaboration of any kind. However, perhaps the relatively unconstrained elaboration predicted by the convergence principle for the combination of verbally provided relationships and a verbal production task reduced the memorabilty of the object concepts themselves as well as the concept of their relationship. If so, then it should be possible to raise both cued recall and recognition of nouns in provided relationships with a different orienting task. This possibility was tested in Experiment 2.

Strategies

The validity of conclusions based on introspection is of course suspect, and the case for convergent elaboration does not depend on subjective reports. Nevertheless, the fact that a correlation between the imagery value of stimuli and their recall has been verified in numerous

studies must be addressed by any alternative explanation of imagery effects. Strategy usage percentages were therefore collected as supplementary evidence for or against the convergence hypothesis. Since introspection is the necessary base on which claims for the mnemonic value of conscious imagery ultimately rest, a demonstration that the amount of imagery experienced in considering a concept and the extent to which the concept is recalled can vary independently would suggest that stimulus imageability is not a complete answer.

The strategy reports provide little evidence for an imagery-based account of memory effects. In particular, the common assumption that the conceptual processing of pictures preserves their perceptual quality, making the picture superiority effect quintessentially an imagery effect, received scant support. Although participants who were shown pictures certainly averred that imagery accompanied their transformation of these stimuli into sentences, they reported other forms of elaboration as equally prevalent, and they reported even less imagery than did participants given verbal stimuli.

Possibly the conscious component of evaluating object concepts and preparing a response was not experienced as "visualizing objects" to as great an extent when the stimuli were pictures as when they were words. This

interpretation, although salvaging an imagery interpretation of the memory effects found in Experiment 1, would seem to necessitate a re-evaluation of the prevalent assumption that the "images" evoked by words, although weaker than the "images" processed during visual perception, are phenomenologically very like them (e.g., Farah, 1985; Finke, 1985; Keenan, 1983).

Regardless of whether the stimuli were pictures or words, imagery dominated when relationships were generated, and verbalization dominated when relationships were provided. Regardless of whether the source of the relationships was external or internal, imagery dominated for words, and verbalization dominated for pictures. The latter result seems to indicate a propensity for dual coding. Yet there was no correlational evidence of an advantage for this dual coding.

One correlation that would have supported a dual-coding interpretation--a positive one between recall and the amount of imagery reported with words--occurred only for words in provided relationships. Furthermore, at .26, this correlation was even less impressive than the .34 correlation between recall of these words and usage of a relational strategy.

Discrepancies between the reported use of a verbal strategy and the pattern of recall also pose problems for a dual-coding account. To support an advantage for dual over

amodal processing, verbalization should be an especially useful strategy with pictures or in conjunction with deliberate image construction. But although more "thinking of the names" was indeed reported with pictures than with words, the usage pattern had no clear relevance to recall. To to further confound a dual-coding interpretation of the recall results, a combination imaginal-verbal strategy (Table 3) was apparently no more used, or useful, than any other, in any condition.

The negative correlations are also suggestive. It seems that imaginally elaborating a generated relationship can actually depress recall, especially for pictures (-.39), and covert naming seems to be an unfortunate strategy in all circumstances. Furthermore, speaking without thinking (the "none" strategy), although reportedly a rare experience in all conditions, may be particularly unhelpful (-.43) for those who might need to remember verbally provided information.

Questions

Even though predictions based strictly on a picture superiority effect were not confirmed, dual coding could be invoked to explain the retrieval results. The task of generating a preposition might have benefited separate word pairs by heightening the vividness of mediational images. Perhaps by comparison the preposition-linked nouns evoked

only vague or fleeting images. Although this possibility seems to strain the dual coding model, which does not claim that the mnemonic advantage of mediational imagery is greater for separate words than for coherent prose (Paivio, 1971, 1986), it was considered in Experiment 2.

Experiment 2: Equating the Mnemonic Value of Words and Pictures Through Generated Imaginal Elaboration

Experiment 1 demonstrated that words can promote recall as effectively as pictures when a relationship is generated. To determine whether either imaginal mediation or semantic generation is a sufficient explanation of this finding, Experiment 2 considered the ways in which the pattern of recall that occurred with the verbal task of Experiment 1 might be altered when the orienting task was explicitly imaginal. As in Experiment 1, two predictions could be made, depending on the mnemonic theory invoked.

Experiment 2 Predictions

Extensive Elaboration Predictions

Whether a concept should be more extensively elaborated in forming an image of the picture of an instance or in forming an image of an instance while reading the name is unclear from a dual coding perspective. If only the hypothesized additive effect of two codes is considered, a prediction opposite to that of Experiment 1

might be made: higher recall for words plus images, lower for pictures plus images. However, the dual-coding proposition that pictures evoke their labels more readily than the labels evoke images (Paivio, 1971, p. 179) confuses the issue, since it suggests that even with an imaginal orientation, pictures might be more likely than words to be coded in two ways, so that the predictions of Experiment 1 might still be made: higher recall for pictures, lower for words. The operation of both propositions--that words benefit from deliberate imagery and that pictures tend to be automatically labeled--could also mean that the probable result of an imaginal orientation would be both verbal and visual representation with either pictures or words. In order to do justice to the dual-coding account of the mnemonic value of imaginal elaboration, it therefore seemed necessary to predict high recall for both pictures and words in Experiment 2, as indicated in Table 5.

Evidence of the efficacy of images as a retrieval-enhancing second code should be provided by the image-vividness ratings as well as by the strategy reports. If images are induced more directly by pictures than by words, then pictures should promote the more vivid imagery. Since the task requires attention to specific relationship, the most vivid images might be expected with pictures that

provide these relationships. The weakest images might be expected with separate nouns for which relational images must be constructed. If memory performance depends on imagery, it should correlate with these values. Furthermore, the correlation should be higher for words, for which images would provide the dual code, than for pictures, for which verbal coding would be crucial.

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
Extensive Elaboration	High	High	High	High
Convergent Elaboration	Low	High	High	High

Table 5. Extensive elaboration and convergent elaboration recall predictions for pictures and words in provided and generated relationships with imaginal orienting task.

If imaginal elaboration confers a retrieval advantage, positive correlations between recall and the strategy-report estimates of relative reliance on imagery should also occur. The correlation should be highest with separate words, the stimuli for which an imaginal code is presumably most needed. Conversely, the correlation between recall and a verbal strategy should be higher with pictures than with words.

Convergent Elaboration Predictions

As Table 5 shows, predictions based on convergence of elaboration again partially accord with those based on the principle of extensive elaboration. Like an imagery effect, a convergence effect would mean high recall for both word conditions and for picture pairs which are to be imaginally related. However, a convergence effect would mean low recall for pictures that leave little to the imagination.

Since convergence predictions depend on the degree to which the combination of stimulus characteristics and processing orientation concentrate elaboration on the cue-target relationship, recall was not expected to duplicate the pattern obtained with the verbal task of Experiment 1. In fact, instructions to visualize the relationship were expected to eliminate the picture superiority effect for provided as well as generated relationships.

With a task explicitly directing processing to perceptual associations, the more rudimentary stimuli should have the advantage. Since decontextualized words carry the minimum obligatory perceptual baggage, they are especially versatile. In the context of an imaginal paired-associate task, they should evoke only the perceptual associations that are consistent with the primed relationships. Accordingly, there seemed no compelling reason to expect more or less convergence on a relationship

when elaboration was constrained by a given preposition than when it was constrained by a choice of two prepositions, so high recall was predicted in both word conditions.

Whereas the latitude permitted by a phrase would promote elaboration that converged on the specified relationship, the irrelevant detail in the picture of a particular interaction would induce elaboration that diverged from the relational concept. Unlike the task of verbalizing this interaction, which would counteract the inherently wide scope of pictorial processing, an imaginal orientation would encourage divergent elaboration. Therefore the poorest recall should occur with pictorially provided relationships.

The speculation, discussed under Elaborative Convergence Predictions for Experiment 1, that the divergent elaboration induced by perceptual detail in the separate pictures might make them less amenable than their labels to relational convergence seemed justified by the trend in the cued-recall data of Experiment 1 (an 8-percentage-point advantage for Words, Generated, over Pictures, Generated). However, since this difference was not significant, it was assumed that any tendency toward elaboration of the pictured objects as separate concepts would be counteracted by the attempt to imagine an

integrated concept. Therefore high and equal recall was again predicted in both generation conditions.

Because prior experience with a relational concept should reduce the search for associations relevant to such a concept, a recall advantage was again predicted for likely pairings. As in Experiment 1, the likelihood advantage was expected to be greater for generated than for provided relationships. However, because this likelihood effect would reflect the strength of the cue-target association, it was not predicted in recognition.

Elaborative convergence would not predict a strong correlation between recall and image vividness ratings or the reported use of an imaginal strategy. Assuming that imagery is the conscious product of an unconscious elaborative process, its vividness might indicate the strength of perceptual associations which are either relevant or irrelevant to the relational concept on which cued recall depends. Even though reported image vividness may well reflect the explicitness of the stimuli or the relational cohesiveness of the task and thus may often covary with recall, certain combinations of stimuli and task should intensify the impression of imagery without promoting the appropriate convergence. In such conditions --i.e., with interactive pictures, which, while providing the target relationship, also show distinctive features extraneous to it--relational processing should be

attenuated and retrieval should suffer, even though the stimulus may be rated highly imageable.

Summary of Experiment 2 Predictions

The stimuli were those shown in Experiment 1: pairs of pictures or their labels, either separate or interactive. The orienting task was to rate the vividness of one's image of a (or the) relationship between the items. The pattern of cued recall was again expected to invalidate explanations based exclusively on either stimulus or task effects.

Contrary to the picture superiority effect, high recall was predicted for words as well as for pictures when a cue-target relationship was generated, and higher recall was predicted for words than for pictures when a relationship was provided; contrary to the generation effect, high recall was predicted for provided as well as for generated pictures. Furthermore, contrary to the imagery effect, an imaginal task was not expected to promote recall of interactive pictures, and neither imagery vividness ratings nor reported reliance on an imaginal strategy was expected to correlate with recall. As before, the more likely pairs were expected to be better recalled across conditions.

Experiment 2 Method

Design and Subjects

With the exception of the orienting task, the design was identical to that of Experiment 1. The 114 righthanded undergraduate participants were recruited from the same subject pool as were those in Experiment 1 but during the following semester. Although both genders were represented in every stimulus-task condition, women predominated by a ratio of six to one.

Materials

A form for rating image vividness was added to the materials used in Experiment 1. It consisted of a sample five-unit scale and 30 horizontal spaced arrays of the numerals 1 to 5, plus four practice arrays. Although there were only 20 experimental stimulus pairs, the extra 10 rating scales were included to prevent anticipation of the end of the list and differential processing of the final stimuli. (Appendix E shows this rating form.)

Procedure

Experiment 2 was conducted in a classroom, in groups of from 14 to 16 undergraduates.

Instructions. The procedure was described as a study of the usefulness of visual images in making judgments about things that are easy to visualize.

In the Relationship-Provided conditions, subjects with Picture stimuli were told to "hold the image of the

relationship"; subjects with Word stimuli were told to "form an image of the relationship." In the Relationship-Generated conditions, subjects with Picture stimuli were told to "form an image that relates the objects so that the one shown on the left of the screen is in or on the one shown on the right"; subjects with Word stimuli were told to "form an image relating the objects so that the one named on the left of the screen is in or on the one named on the right." (The basic Imaginal Task instructions for Relationship-Provided and Relationship-Generated stimuli, each with the variations in wording used in the Picture and Word conditions, are in Appendix D.)

Regardless of Source of Relationship or Stimulus Mode, the task was described as rating the vividness of "your image." The experimenter stressed the importance of doing the ratings conscientiously, explaining that these ratings would be compared with those of students in other groups.

Training. The experimenter distributed the image vividness rating forms (Appendix E) and told the students to use the practice scales at the top, then presented the same four training stimuli seen by subjects in the corresponding condition of Experiment 1. Before starting the acquisition sequence, the experimenter ascertained that all participants felt confident about their ability to perform the rating task.

Acquisition and testing. Each group saw one of the eight videotaped sequences used in Experiment 1. In order to help the students to relax and concentrate on visual imagery, the experimenter dimmed the room lights and sat out of sight behind a carrel during the acquisition stage of the procedure. As in Experiment 1, the videotape was stopped unexpectedly after the asterisk display signalling the onset of stimulus pair 21. Then the experimenter restored the normal lighting, collected the imagery rating forms, and presented the strategy-reporting task as the purpose of the study. The only variation from the procedure of Experiment 1 during the rest of the session was that in order to prevent communication among the participants, the experimenter remained visible.

Experiment 2 Results

Retention

As in Experiment 1, the initial analyses showed no List or Gender effects, so the data were collapsed across these factors. As Table 6 indicates, imagery instructions did not just eliminate the picture superiority effect but reversed it in both tests of retention.

Cued recall. For each of the following between-group F ratios, MS_e (1,110) = 825.9. The attempt to form interactive images produced a main effect for Stimulus Mode (Pictures, 58.4%; Words, 71.1%; F = 11.5 and a Mode x Source interaction (F = 8.9. This significance was due

entirely to a disadvantage for interactive pictures. Phrases prevailed in the Relationship-Provided conditions [Pictures, 49.5%; Words, 73.8%; $\underline{t}$ (26) = 3.2], and separate pictures prevailed in the Picture conditions [Provided, 49.5%; Generated, 66.8%; $\underline{t}$ (27) = 2.3]. Neither of these effects is compatible with either the imagery or the generation predictions shown in Table 5.

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(28)	(28)	(30)	(28)
CUED RECALL:	49	74	67	68
Likely	57	76	73	78
Unlikely	42	71	61	59
RECOGNITION:	72	89	82	88
Likely	78	91	88	92
Unlikely	66	88	76	85

Table 6. Percentage recall and recognition of pictures and words in provided and generated likely and unlikely relationships with imaginal orienting task (Exp. 2).

They are compatible with convergence predictions, as is the high recall in the Word conditions (Provided, 73.8%;

Generated, 68.4%) and the statistical equivalence of these means and the 66.8% recall for Pictures, Generated. Nevertheless, this pattern of recall would also accord with an interpretation of generation effects that included imaginal generation, so further evidence of the causal role of differential convergence seems to be needed.

The case for an elaborative convergence interpretation is strengthened by the breakdown of scores in Table 6. The more likely relationships again had an over-all recall advantage [Likely, 71.1%; Unlikely, 58.2%; $\underline{F}$ (1,110) = 40.5, $\underline{MS}e$ = 231.3], and this advantage again did not interact with Stimulus Mode nor with Source of Relationship, although a three-way Mode x Source x Likelihood interaction did occur ($\underline{F}$ = 4.6). The difference produced by Likelihood was significant in all conditions except Words, Provided, in which even the unlikely pairings benefitted from an imaginal orientation.

Recognition. As the scores in Table 6 indicate, recognition raised the retrieval level [Recall, 64.6%; Recognition, 82.8%; $\underline{F}$ = 230.8, $\underline{MS}e$ (1,110) = 81.4] but did not appreciably change its pattern. For every between-subjects $\underline{F}$ ratio reported for recognition scores, $\underline{MS}e$ (1,110) = 331.0. The cued-recall main effect of Stimulus Mode was maintained (Pictures, 77.1%; Words, 88.7%; $\underline{F}$ = 23.8, but no Mode x Source interaction

occurred. Although recognition in the three high-recall conditions did not differ significantly, recognition of the Pictures, Provided, targets (71.8%) was inferior to that of the other conditions by at least 10 percentage points [*t* (28-29) = 2.1 to 3.6]. That is, the attempt to retain images of pictures impaired memory for the items as well as for the relationships depicted.

In Experiment 1, the likelihood effect that occurred in cued recall was eliminated in recognition. In Experiment 2, this effect was apparent in both recall and recognition [Likely, 87.1%; Unlikely, 78.4%; *F* = 34.3, *MS*e (1,110) = 123.3]. Likelihood interacted with Stimulus Mode (*F* = 5.5) but not with Source of Relationship. As the breakdown of scores in Table 6 indicates, the conditions in which items presented in the more likely contexts were better recognized were the same conditions in which they were better recalled when cued by a contextual element [*t* (26-28) = 2.4 to 4.2]. The recognition advantage for targets from likely contexts was nonsignificant only for Words, Provided (Likely, 90.7%; Unlikely, 87.5%).

Reported Strategies

As would be expected with an explicitly imaginal task, every strategy with a reported usage of over 20% involved imagery. Table 7 shows that whereas pure *I* was reported more with verbal than with pictorial stimuli, *I-R* was the dominant strategy in all conditions except Pictures,

Provided, for which I-V was preferred. Nevertheless, as the Pearson r coefficients in Table 7 reveal, none of this experienced imagery improved recall. The only significant correlations were negative. (With df = 26-28, the critical r values for one-tailed tests are .317-.306, and for two-tailed tests, .374-361.) With Words, Provided, both V (-.499) and R (-.493) seemed to be inappropriate strategies, and with Pictures, Provided, I (-.452) was apparently the wrong approach.

As before, the eight strategies were collapsed into three basic strategies in order to clarify their effects. Imagery remained by far the dominant strategy (I, 85.6%; V, 41.3%; R, 45.8%). But some between-group variations appear in Table 8 that are less apparent in Table 7.

The incidence of reported I was especially high for verbal stimuli [Pictures, 80.7%; Words, 90.6%; t (55) = 1.9], and the affinity between words and I was even greater when relational generative was required [Pictures, Generated, 79.5%; Words, Generated, 94.4%; t (26) = 2.1]. With relationships provided, Stimulus Mode did not significantly affect I (Pictures, Provided, 81.9%; Words, Provided, 86.8%;). Nevertheless, generation per se did not increase I for either Pictures (Provided, 81.9%; Generated, 79.5%) or Words (Provided, 86.8%; Generated, 94.4%).

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(28)	(28)	(30)	(28)
CUED RECALL:	49	74	67	68
IMAGINAL:				
% Usage	17	26	18	28
Usage-Recall r	-.45**	.19	.20	-.11
IMAGINAL-RELATIONAL:				
% Usage	13	34	40	38
Usage-Recall r	-.10	.29	.01	.10
VERBAL:				
% Usage	14	6	8	3
Usage-Recall r	-.06	-.50**	-.15	-.19
VERBAL-RELATIONAL:				
% Usage	1	0	5	2
Usage-Recall r	-.14	--	-.26	-.06
IMAGINAL-VERBAL:				
% Usage	39	17	14	18
Usage-Recall r	.17	-.15	-.21	.00
IMAGINAL-VERBAL-RELATIONAL:				
% Usage	13	9	8	11
Usage-Recall r	.28	.19	.16	.08
RELATIONAL:				
% Usage	2	4	3	1
Usage-Recall r	.06	-.49**	.16	-.14
NONE:				
% Usage	1	4	5	1
Usage-Recall r	-.33	-.18	.00	-.13

Table 7. Percentage reported usage of eight strategies with imaginal orienting task, and correlation of strategy usage with recall (Exp. 2).

** = $p < .01$

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(28)	(28)	(30)	(28)
CUED RECALL:	49	74	67	68
IMAGINAL STRATEGY:				
% Usage	82	87	80	94
Usage-Recall *r*	.09	.49**	.13	.24
VERBAL STRATEGY:				
% Usage	67	32	34	33
Usage-Recall *r*	.38**	-.15	-.18	.01
RELATIONAL STRATEGY:				
% Usage	27	46	56	53
Usage-Recall *r*	.18	.25	.06	-.10

Table 8. Percentage reported usage of three basic strategies for pictures and words in provided and generated relationships with imaginal orienting task, and correlation of strategy usage with recall (Exp. 2).

** = $p < .01$

Although the percentages reported for both Verbal and Relational processing were relatively low, each of these strategies was also influenced by stimulus variables. The use of V was significantly greater with interactive

pictures than with any other stimuli [Pictures, Provided, 66.5%; Words, Provided, 32.1%; Pictures, Generated, 33.8%; Words, Generated, 33.1%; *t* (27-28) = 4.5 to 4.7]. The use of R showed the opposite pattern with relationships provided [Pictures, Provided, 27.4%; Words, Provided, 46.4%; *t* (26) = 2.6] and with relationships generated, R was high in either mode (Pictures, Generated, 55.6%; Words, Generated, 53.1%). An increase in R usage with generation occurred with Pictures [Provided, 27.4%; Generated, 55.6%; *t* (27) = 3.9] but not with Words (Provided, 46.4%; Generated, 53.1%).

In other words, reported I was unrelated to the pattern of recall, since it was as high for Pictures, Provided, as for Pictures, Generated, or Words, Provided; reported V was inversely related to the pattern of recall; and reported R parallelled the pattern of recall: significantly lower with Pictures, Provided, than with the other three conditions. These observations are offered only as preliminary information. The issue addressed by this research is not the extent to which a strategy is used but the extent to which its usage is mnemonically effective. As the *r* values in Table 8 indicate, each of the strategies had its value for particular stimulus-task combinations, but none was impressive in all cases.

The Usage-Recall correlation of reported I (.251) was significant but low across conditions. (For *df* = 112, the

critical one-tailed *r* value is .160.) Within conditions, the I experience to some extent reflected I effectiveness, since the correlations were lower with pictures than with words, and for Words, Provided, a respectable correlation occurred (.487). However, for Words, Generated, the condition which dual coding theory should expect to benefit most from mediational imagery, the correlation was low and nonsignificant (.238).

Usage and effectiveness corresponded to some extent with a V strategy, as well, since the condition in which the most V was reported, Pictures, Provided, produced a low-to-moderate Usage-Recall correlation (.380). Yet V was apparently ineffective in all of the high-recall conditions, including Pictures, Generated (-.182), a condition in which, by dual-coding criteria, it should be a major determinant of recall. R, although reportedly used more in the generated conditions, seemed to be more useful when relationships were provided, although the highest Usage-Recall correlation for R (Words, Provided, .252) was not significant.

Image Vividness Ratings

As Table 9 shows, mean image vividness ratings did not parallel recall. Despite the disadvantage in recall for Pictures, Provided, images based on pictures were rated as vivid as those based on words on the 5-point scale

SOURCE OF RELATIONSHIP:	Provided		Generated	
STIMULUS MODE:	Pics	Words	Pics	Words
n:	(28)	(28)	(30)	(28)
CUED RECALL:	49	74	67	68
IMAGE VIVIDNESS:	4.0	3.7	3.1	3.3
Likely	4.1	4.1	3.7	4.0
Unlikely	3.9	3.3	2.6	2.7
VIVIDNESS-RECALL r:	.21	.27*	.49**	.64**
Likely	.22	.31	.47**	.60**
Unlikely	.03	.12	.34	.34

Table 9. Image vividness ratings (1-5) and correlation of vividness with recall for pictures and words in provided and generated likely and unlikely relationships (Exp. 2).

* = $p < .05$; ** = $p < .01$

(Pictures, 3.5; Words, 3.5), and the attempt to generate a nonspecified relationship reduced, rather than increased, the sense of image vividness [Provided, 3.85; Generated, 3.23; F (1,110) = 25.7, MSe = 84.3]. Furthermore, the detrimental effect of generation on imagery was due primarily to the difficulty of generating an interactive image of separately pictured objects [Pictures, Provided, 4.0; Pictures, Generated, 3.1;

t (27) = 3.6]. When the stimuli were verbal, generative processing did not significantly impair imagery (Words, Provided, 3.7; Words, Generated, 3.3).

A comparison of the rated vividness of the image induced by each stimulus and recall of that stimulus testifies further to the fallacy of the idea that imaginal processing always improves memory. The overall correlation of image vividness and recall was an unimpressive .033. However, with the critical *r* = .22 (for a two-tailed test with *df* = 78), the correlation was weakly significant with verbal stimuli (Pictures, .11; Words, .29) and strongly significant with generated concepts (Provided, -.06; Generated, .56;).

As Table 9 also reveals, likelihood strongly affected imageability in all conditions as well as over-all (Likely, 4.0; Unlikely, 3.1; *F* = 230.7; *MS*e = 17.20. The likelihood advantage is apparent in the Vividness-Recall correlations, particularly when the relationship between Likely pairings was Generated (*r* = .56), and most of all when these separate, plausible pairs were presented as Words (*r* = .60).

One other curious finding about experienced imagery makes claims for its mnemonic value rather dubious: The usage of an imaginal strategy reported by each subject did not correlate with that subject's judgments of image

vividness (I-Vividness r = .08). The I-Usage-Vividness correlation for Words, Provided, the only condition with a significant I-Recall correlation (see Table 8), was nonsignificant [r (26) = .30], and the level of reliance on an imaginal strategy in the other conditions had even less relevance to the reported quality of the images (r = -.10 to .07).

As a final test of the role of imagery in the differential recall produced by an imaginal task, the subjects were split into equal groups of high and low (H and L) "imagers" on the basis of their mean vividness ratings. Slightly more women (52%) than men (44%) were in the H category, which constituted exactly 50% of the subjects in each task-stimulus condition. The high imagers did recall more than low imagers [H, 69.1%; L, 60.2%; F (1,106) = 5.6, MSe = 808.0], and the difference was consistent in every condition.

The two groups differed in their reliance on an Imaginal strategy (I, H, 91.4%; I, L, 84.2%), but the difference was due entirely to their approach to relationships which were Provided. This difference was as pronounced for Words, Provided (I, H, 96.1%; I, L, 77.5%) as for Pictures, Provided (I, H, 98.4%; I, L, 82.3%). The groups used imagery to the same extent for relationships which they Generated (I, H, 85.6; I, L, 88.4%).

High imagers also tended to report more usage of a Verbal strategy than did low imagers (V, H, 44.7; V, L, 38.7), and the difference was greater for Words (V, H, 37.8%; V, L, 27.8%) than for Pictures (V, H, 51.6%; V, L, 49.6%). However, low imagers reported more relational processing (R, H, 42.2%; R, L, 49.3%) in every condition except Pictures, Generated. In other words, no matter how the quality of imagery was assessed, it did not explain the low recall of the interactive pictures.

Discussion of Experiment 2

The main question addressed by Experiment 2 was the effect of provided or generated elaboration on the mnemonic value of visual imagery. Subjects were required to rate the vividness of their imaginal representations of relationships between pairs of objects. The relationships were evoked by stimuli at four levels of perceptual and conceptual explicitness. Later, a surprise test of recall of one member of each pair was cued by the other. If the picture superiority and generation effects produced in Experiment 1 by a verbal task were really imagery effects--that is, if image formation was automatic when pictures were presented or when a relational concept was generated but not when the concept was provided by words--then both effects should have disappeared in Experiment 2: (1) The deliberate formation of images should have raised recall in the Words, Provided, condition to the level achieved in the

Words, Generated, condition, and (2) Picture pairs should have produced superior recall, as in Experiment 1, whether relationships were provided or generated.

Memory

Experiment 2 confirmed the predictions of a convergence account of elaboration (see Table 5). The picture superiority effect was not only eliminated but reversed by an explicitly imaginal task. Memory for interactive pictures was significantly worse than memory for words. The generation effect, which in Experiment 1 occurred only with words, occurred only with pictures in Experiment 2. (Figure 2 provides a simplified reminder of these results, which are presented in greater detail in Table 6.) The imaginal task focused elaboration on perceptual aspects of the cue-target relationship, and the stimulus pairs which profited most from this focus were the less explicit ones--those lacking either all perceptual particulars or particulars about their relationship, the pairs which, without such a constraining task, might have been diffusely or irrelevantly elaborated. The pairs which profited least were those providing a surfeit of perceptual particulars--interactive pictures.

While providing relational information, the picture of a particular lamp on a particular turtle also conveys information that is irrelevant to the relationship. It

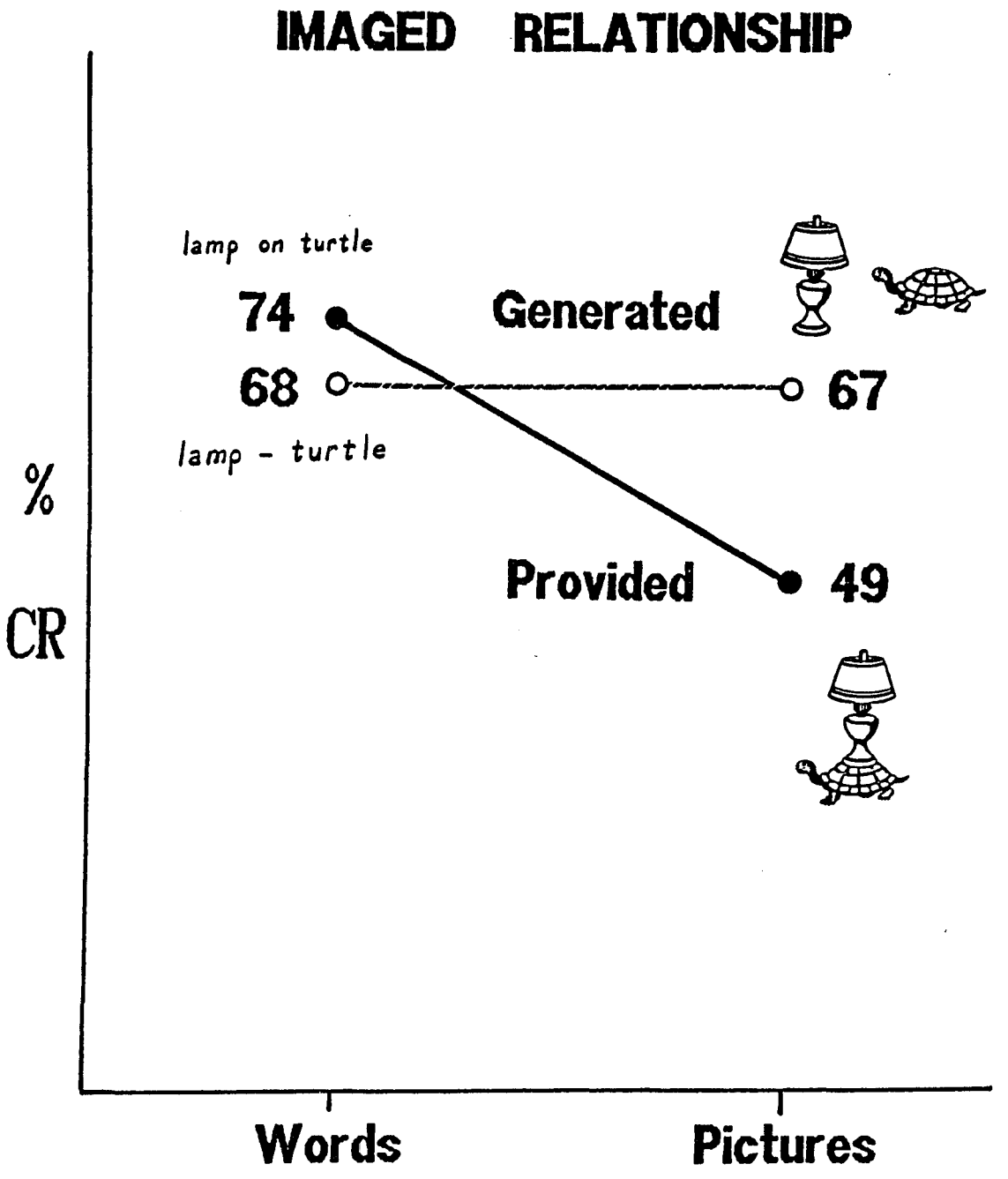

Figure 2. Percentage recall of pictures and words in provided and generated relationships with imaginal orienting task (Exp. 2).

seems likely that with a task requiring imaginal elaboration, this information cannot be ignored. Relative to a three-word phrase, which imposes no particular perceptual associations, interactive pictures would promote superfluous elaboration, precluding a potential subjective instantiation of the relational concept and leaving the integration of cue and target correspondingly weak.

The reversal in Experiment 2 of the apparent picture superiority effect in Experiment 1 (compare Figures 1 and 2) can be explained by a single principle. Generation of the appropriate preposition promoted recall when the cue-target relationship was explicitly depicted, and generation of an appropriate image promoted recall when the relationship was indicated by a phrase. That is, whenever the task directed elaboration more to the relationship than to other explicit information about the separate component concepts or to other implicit associations of these concepts, the effectiveness of one of the components in accessing the other increased. When the relationship was generated, either a verbal or an imaginal orientation promoted recall.

The convergence of elaboration on generated concepts can also explain the elimination in both procedures of the usual superiority of interactive to separate pictures and of relational phrases to unrelated nouns. In Experiment 1

words linked only by a hyphen were better recalled than the same words presented in a comprehensible relationship, and in Experiment 2 pictures that were only adjacent were better recalled than the same pictures combined to show an interactive relationship. There is no doubt about the general vigor of stimulus-provided organization effects. Therefore it seemed excessive to include in the design of either experiment the no-generation, separate-presentation conditions that would more conclusively have demonstrated the mutability of these effects. (This outcome is only mentioned.)

Whereas with the verbal orientation of Experiment 1, likely relationships had an advantage only when they were generated, with the imaginal orientation of Experiment 2, a likelihood advantage also occurred for pictorially provided relationships. It seems plausible that even with a stimulus-task combination that induces the processing of nonsalient perceptual features, the associations between likely pairs promote stronger relational convergence than do the nonspecific associations between unlikely pairs. There was only one exception to the likelihood effect: Nouns presented in improbable phrases were recalled nearly as well as were nouns in more familiar contexts. Since the diffuse processing which ordinarily would be induced by the vagueness of three-word phrases would be even greater when the phrases expressed unfamiliar concepts, the relatively

high recall of these nouns seems to indicate the effectiveness of the imaginal task in imposing perceptual specificity on this processing.

Recognition memory was again similar to that of cued recall, with significantly lower recognition of the names of objects which had appeared in interactive pictures. Even though this result was not predicted, it does seem to disconfirm the possibility that the low recognition of words from relational phrases in Experiment 1 was due to something inherent in these stimuli. Instead, the recognition data suggest that the stimulus-task interaction that determines the accessibility of a relationship between two concepts also affects the accessibility of the concepts as separate events.

Although in Experiment 1 there was no likelihood effect in recognition, in Experiment 2, the pattern of superior recall for likely pairs was retained in recognition. The only exceptions were the words from unlikely phrases, which were both recognized and recalled as well as any other targets. The likelihood effect in recognition was especially strong for items originally presented as pictures. Thus the poorest recognition occurred for items which had been depicted in unlikely relationships, contrary to the supposed mnemonic benefits of pictures, of provided organization, and of bizarreness.

The effort hypothesis. An alternative interpretation of the memory results of Experiments 1 and 2 that has been suggested is that they simply indicate the processing resources needed to comply with the orienting task. By this reasoning, the task of constructing a sentence expressing an "in" or "on" relationship in Experiment 1 might be least effortful in the low-recall condition, since the stimuli provided the content words of the sentence, including the linking preposition. Similarly, the task of constructing an interactive image in Experiment 2 might be least effortful in the low-recall condition, since the stimuli were pictorial and showed the interaction. There are at least three objections to this proposal.

First, the cognitive effort, or capacity, devoted to any task is not an obvious attribute of the task. As pointed out by Mitchell and Hunt (1989), it can only be determined empirically--for example, by measuring the decrement from baseline of performance on a concurrent capacity-demanding task. Such measures reveal that more processing resources may, in fact, be allocated to the seemingly easier task (Britton, Westbrook, & Holdredge, 1978). Therefore, "effort" is not a construct that allows a priori predictions.

Second, if the greater effort required in generating a relationship were a sufficient explanation of the advantage of separate nouns over phrases in Experiment 1 and of

separate pictures over interactive pictures in Experiment 2, then one would expect both effects to operate in both experiments. Presumably, greater effort would also be required to generate relationships between the picture pairs in Experiment 1 and the noun pairs in Experiment 2 than to produce the same overt responses when the relationships in each mode are provided. Yet in these conditions generation of the relationships produced no retrieval advantage.

Third, an effort account implies that novel concepts, because they must be constructed of disparate associative elements, should be more memorable than concepts which are already represented in a unitary form. Therefore higher recall should be expected with unlikely than with likely relationships. This outcome would correspond to the bizarreness effect, the reliability of which is a topic of current controversy (Einstein & McDaniel, 1987). The consistent advantage in both experiments for the pairings rated more likely makes the effort hypothesis--or at least an effort hypothesis based on presumed task difficulty--untenable.

The effect of generation. Although cognitive effort fails as an explanatory construct, the retrieval patterns of both experiments do seem to reflect the extent of subjective generation. Certainly, the task of producing a

complete sentence expressing a particular relationship or of rating the vividness of one's image of a particular relationship necessitated some generation in all conditions, since in no case was the sentence or the interactive picture perceptually available. However, generation was presumably more extensive in some of the eight stimulus-task combinations tested than in others. Not only the Generated conditions but the Provided conditions in which stimuli and task were in contrary modalities produced effective incidental learning. Assuming that the more the stimuli specify the response elements, the less generation is required to produce the response, the sentence production task would be least generative when the stimuli specify the three content words and the image formation task would be least generative when the stimuli depict the interaction. The sentence task would be more generative when only the nouns are provided; the image task would be more generative when the interactive elements are shown as separate objects. An appreciable degree of generation would also be involved in converting input in one modality to output in another--with pictorial input to the sentence task or verbal input to the imaginal task.

From the first studies on the effect, generation has been implicitly defined as verbal production. Although the production required in Experiment 2 was nonverbal, the

results are consistent with the generation-effect perspective outlined. That is, the imagery effect might more generally be called a generation effect. Even so, both terms simply name a processing orientation. Neither one indicates the processing dynamics that produce the effect. Neither generation per se nor imagery per se explains the differential memory produced by either experimental procedure, since every condition required generation, and in Experiment 2 the generation was in every condition imaginal. It was the quality of the elaborative activity induced by the generative task that determined memory. The recall pattern obtained reflects the extent to which subjective elaboration converged on the critical relational concept.

Strategies

In accordance with their instructions, the participants in Experiment 2 reported more reliance on visualization (85.6%) than did those in Experiment 1 (67.5%). However, as a comparison of the imagery values in Tables 4 and 8 suggests, the degree to which imagery is experienced may be as much a function of stimulus condition as of an imaginal orientation. Just as in Experiment 1, the highest incidence of imagery was reported when the stimuli for relational processing were separate nouns (94% in both experiments). Although in contrast to Experiment

1, this imagery value was not significantly higher than that reported with phrases, it was higher than that reported in either picture condition. In other words, although people may be aware of imagery in considering things they have just seen, they are even more aware of imagery when they consider things they have not seen. Furthermore, as the strategy reports of Experiment 1 indicate, the influence of generation on phenomenological imagery may be even greater when the imagery is not deliberate.

Regardless of the complex influence of stimulus characteristics and task demands on the strategy employed, the question of interest is the usefulness of the strategy. Specifically, to what extent did the perceptual elaboration that apparently predominated in all conditions of Experiment 2 promote cued recall? The higher correlation coefficients for words than for pictures in Table 8 do provide some support for a dual-coding advantage, but they also suggest that imagery at acquisition is not a decisive factor in retrieval. Although with both the verbal task of Experiment 1 and the imaginal task of Experiment 2 the highest correlation of imagery usage and recall occurred for phrases, and although with the imaginal task this correlation was significant, recall scores were higher in Experiment 1, and equally high in Experiment 2, in conditions in which they did not correlate with imagery.

The relative usage of a verbal strategy again offers some support to a dual-coding interpretation. However, the correlation data strain this interpretation. The strongest indication of dual coding is the 67% awareness of verbalization that occurred with interactive pictures. Even though this verbalization was apparently insufficient to ensure recall of half the target concepts, its moderate correlation with recall suggests that it did help. Yet the verbalization that occurred during the generation of a relationship between pictured objects was of no value to memory, a result that dual coding would not predict.

The finding that the lowest incidence of relational processing was reported with interactive pictures, the condition of lowest recall, is consistent with an interpretation stressing the necessity of convergence on the relational concepts. However, the finding that a relational strategy was apparently more useful when relationships were provided than when recall depended on their generation seems contrary to common sense. In fact, this anomalous aspect of the correlations between recall and the cognizance of relational thought in both experiments suggests the plausibility of one or more of the following assessments of strategy reports: (1) more of item-specific than of relational processing reaches consciousness, (2) conscious experience has little

correspondence with the processes underlying it, or (3) the reported mental experiences are reconstructions based on common assumptions or on implicit experimenter demands.

Image Vividness

One of the questions addressed in this research is whether the usual relative advantage of certain tasks and stimuli is better explained by the phenomenal experience of vivid imagery or by the specificity of elaboration that this vividness may indicate. If the conceptual linkage of cue and target depends on the formation of mediating images, then cued recall should reflect the quality of these images. But to establish that imagery indicates effective processing and is not merely a common accompaniment of effective processing, it is not enough to show that the conditions of higher recall are those in which images are more vivid. It must also be shown that the better-recalled stimuli are the ones that produce the more vivid images and that the subjects who report more vivid imagery are the ones who have better recall.

The correlation of image vividness and recall was weak or nonexistent when the images were unlikely or when they represented attempts to reproduce pictures (Table 9). The vividness-recall correlation was stronger for likely concepts, especially those which were not perceptually explicit in the stimuli. The correlation was strongest when both the item-specific and the relational features of

the concepts were generated. So although the intensity of the imaginal experience does not reliably indicate the efficacy of the processes underlying memory, it does seem to indicate the degree to which conceptual generation is involved in the processing.

The median split between high and low "imagers" supports this interpretation. When relationships were provided, students who rated their images especially vivid also reported more reliance on imagery than did students who rated their images on the dim side. However, when relationships were generated, imagery was not only the favored strategy but it was favored equally by all, despite differences in the vividness of the experience.

Questions

Experiments 1 and 2 each provide evidence that relative recall depends on the joint suitability of stimulus characteristics and processing orientation for directing associative elaboration to the relationship between cue and target. Targets for which this relationship was provided were well recalled only if the task narrowed the scope of processing so that relational associations were preferentially elaborated: In Experiment 1, sentence production required consideration of the relational aspects of pictures, and in Experiment 2, visualization required consideration of the relational

aspects of phrases. Recall suffered if the task induced irrelevant elaboration: In Experiment 1, sentence production encouraged indiscriminant attention to the separate words in phrases, and in Experiment 2, visualization encouraged indiscriminant attention to the nonrelational features of complex pictures.

Yet as results in the generation conditions of both experiments show, high recall did not depend on stimuli and task being in complementary modes. The symbols that initiated processing, whether verbal or pictorial, were not what mattered; and the output of processing, whether overt or covert, verbal or imaginal, was not what mattered.

Elaborative convergence predicts that targets for which a relationship is generated will be precisely integrated with their cues, especially when the generation involves elaboration of a familiar concept that is not countermanded by the stimuli. Thus separate pictures that subjects verbally elaborate as interacting objects and separate words that subjects imaginally elaborate as interacting objects should not only each be higher on the recall continuum than the corresponding integrated stimuli; they should be recalled equally well.

The much stronger positive correlation between image vividness ratings and recall when relationships were generated than when they were provided is consistent with the hypothesis that visual imagery and verbal generation

are alternative conscious components of preconscious elaboration and that the mnemonic effectiveness of either depends on the relational convergence of this elaboration. To provide further support for this hypothesis, a direct comparison of imagery and generation effects was needed.

Although Experiments 1 and 2 were nearly identical procedurally, the difference between the verbal and imaginal orienting tasks prevents the comparison of their outcomes. Experiment 1 required the production of an overt response in a private session; Experiment 2 required the evaluation of a covert experience in a group session. It remained to be shown that a form of covert elaboration which would not be interpreted as imagery could influence recall in the same way as do imagery instructions and that a measure of its convergence could correlate with recall in the same way as do image vividness ratings. Experiment 3 was designed to equalize the conditions for verbal and imaginal generation so that their effects on both recall and task-recall correlations could be compared.

Experiment 3: Equating the Mnemonic Value of Verbal and Imaginal Generation

The third experiment provided a means of comparing the results of the other two. It asked whether the elimination of the picture superiority effect found with verbal

generation in Experiment 1 and with imaginal generation in Experiment 2 would occur with procedures that were strictly comparable. In other words, it asked directly whether there is anything special about imagery--or whether image formation is functionally equivalent to verbal generation.

The effects of two orienting conditions, verbal and imaginal, were compared. Both conditions required the generation of a relationship, but in contrast to the tasks of Experiments 1 and 2, the relationship was the same in all cases: the object named or pictured on the left of the screen was to be placed <u>on</u> the one on the right. By removing the decision-making component of generation, this change not only ensured more consistency between items and between subjects but eliminated a complexity that may have prolonged the processing that precedes conceptual convergence.

Aside from this simplification, the only procedural changes were in the verbal task. Whereas speech production was required in Experiment 1, in Experiment 3 the generated sentences were not to be overtly expressed. Since it is the underlying processing that produces the generation effect and not actual articulation (Slamecka & Fevreiski, 1983), this change was not expected to affect the outcome. In addition, to ensure compliance with instructions while making the verbal condition even more similar to the imaginal, a rating task appropriate to sentences was added.

The imaginal task was the one used in the generation condition of Experiment 2: to form a visual image of each relationship and to rate this image on its vividness. The verbal task was equally covert: to mentally construct a sentence expressing each relationship and to rate this sentence on its likelihood.

Experiment 3 Predictions

The predictions for each of the two views of elaboration were those made for the generation conditions of Experiments 1 and 2. That is, Table 10 combines the predictions shown under "Generated" in Tables 1 and 5.

STIMULUS MODE:	Pictures		Words	
GENERATION TASK:	Imaginal	Verbal	Imaginal	Verbal
Extensive Elaboration	High	High	High	Low
Convergent Elaboration	High	High	High	High

Table 10. Extensive elaboration and convergent elaboration recall predictions for pictures and words imaginal generation and with verbal generation.

Extensive Elaboration Predictions

If a strategy of elaborative image formation were the most effective way to improve memory for concrete concepts, recall in every Imaginal cell should be better than in the

corresponding Verbal cell. However, taking into account the dual-coding hypothesis that imagery effects result from the augmentation of verbal processing by concurrent imaginal processing, high recall would be expected for Pictures given Verbal labels as well as for Words given Imaginal elaboration. Furthermore, the dual-coding explanation of the picture superiority effect--that labeling tends to be automatic in picture comprehension--should make Pictures as effective with an Imaginal as with a Verbal orienting task. Therefore, as shown in Table 10, the only stimulus-task combination not liable to show the effect of extensive elaboration is that of Words which are given only Verbal coding.

Extensive Elaboration Predictions

Since only separate picture or word pairs were presented in Experiment 3, it was necessary to activate, or "generate" conceptual knowledge in every condition in order to rate the specified relationship. If instructions to verbalize nonpresented relationships in Experiment 1 and to form images of nonpresented relationships in Experiment 2 both enhanced recall in the Generated conditions not by increasing elaboration but by focusing it appropriately, then high recall should result with either form of generation. Furthermore, words and pictures should be equivalent stimuli for either form of generation. The

convergence principle predictions of uniformly high recall across conditions shown in Table 10 would not be an obvious result of either imagery or verbal generation as distinct phenomena. It might be expected only if the mnemonic value of generating images and of generating words were a function of the associative convergence they ensured between cue and target concepts.

Summary of Experiment 3 Predictions

With separate stimulus pairs in all conditions and comparable rating tasks, Experiment 3 directly tests the relative mnemonic efficacy of verbal generation and visual imagery with verbal and pictorial stimuli. Contrary to the picture superiority effect, contrary to the imagery effect, and contrary to a generation effect based on the conception of generation as a verbal phenomenon, each of the four stimulus-task combinations is expected to promote high recall. The interpretation of this outcome in terms of imaginal elaboration is expected to be invalidated, as before, by evidence that reported imagery usage does not correlate with recall. Correlations of recall with imagery vividness and sentence likelihood ratings are expected to indicate that imaginal and verbal generation are equivalent in their effect. As in the earlier procedures, an advantage for the more likely relationships is also predicted.

Experiment 3 Method

Design and Subjects

The design essentially combined the Generation conditions of Experiments 1 and 2. There were four binary factors: Stimulus Mode (Pictures or Words), Generation Task (Imaginal or Verbal) and List (1 or 2) beween subjects and Likelihood of Relationship (Likely and Unlikely) within subjects. The participants were 115 righthanded undergraduates, 87 women and 28 men. Each of the eight Stimulus Mode x Generation Task x List groups had from 12 to 17 participants. Although both genders were represented in every group, no gender differences were expected and so no attempt was made to equalize the percentage of men in the groups.

Procedure

There were only two departures from the Generation procedure of Experiment 2: (1) Instead of being required to choose between an "in" and an "on" relationship for each stimulus pair, the students were given only the "on" relationship to consider; (2) The Verbal task closely approximated the Imaginal task. For Imaginal Generation, the task was to form a visual image of the object pictured or named on the left of the screen resting on the object pictured or named on the right and to rate this image on its vividness. For Verbal Generation, the task was to compose a complete sentence of the form "The (name of the

object on the left) is on the (name of the object on the right)" and to rate this sentence on the likelihood of its occurrence in print or speech. (The instructions are in Appendix D; the rating forms are in Appendix E.)

Although generation is customarily confirmed by vocal production, a generation effect has been demonstrated without overt expression of the generated concept (Slamecka & Fevreiski, 1983). Furthermore, subjective reports are the only possible confirmation that an imaginal experience has occurred. So even though the required sentence would not be spoken, its construction to a level of awareness that allowed its likelihood to be rated was considered sufficient to test the proposition that imaginal and verbal generation are essentially identical processes.

Experiment 3 Results

Retention

Neither Gender nor List had a significant effect in any analysis, so the data were pooled as before.

Cued recall. As shown in Table 11, recall was high in all conditions, from 71.6% to 80.9%. Consistent with the predictions of convergent elaboration shown in Table 10, neither Stimulus Mode nor Generation Task nor their interaction had a significant effect in the ANOVA, and *t* tests confirmed the equivalence of recall in all between-subject conditions. Likely relationships were better

recalled over all than Unlikely [79.2% vs. 69.5%; F (1,111) = 34.6, MSe = 156.2], and Likelihood did not interact with Mode or Task. The likelihood effect occurred with Pictures, regardless of Task, and with Words and Imaginal Generation [t (23-30) = 3.06-3.89]. However, with Words and Verbal Generation, Unlikely cues were as effective as Likely ones.

STIMULUS MODE:	Pictures		Words	
GENERATION TASK:	Imaginal	Verbal	Imaginal	Verbal
n:	(25)	(32)	(29)	(28)
CUED RECALL:	72	73	72	81
Likely	77	79	78	83
Unlikely	66	67	65	79
RECOGNITION:	86	87	88	94
Likely	89	91	91	95
Unlikely	83	82	85	93

Table 11. Percentage recall and recognition of pictures and words in likely and unlikely relationships with imaginal generation and with verbal generation (Exp. 3).

Recognition. Although the nature of the Generation Task did not affect recognition and Task did not interact

with Stimulus Mode, Words produced better recognition than Pictures [91.2% vs. 86.3%; *F* (1,111) = 6.9, *MS*e = 1384.5]. This main effect was due solely to the superiority of Words with Verbal generation (94.3%) over both Pictures, Verbal [86.6%; *t* (28) = 2.14] and Pictures, Imaginal [86.0%; *t* (25) = 2.16]. Recognition did not differ for Words, Imaginal, and either Picture condition.

The effect of Likelihood of Relationship remained significant in recognition [Likely, 91.7%; Unlikely, 85.9%; *F* (1,111) = 16.1; *MS*e = 1843.5]. In contrast to the results of Experiment 1, in which likelihood had no effect, recognition with Imaginal generation was enhanced when the relationship was familiar: Pictures [Likely, 89.2%; Unlikely, 82.8%; *t* (23) = 2.11]; Words [Likely, 91.0%; Unlikely, 85.2%; *t* (25) = 2.01]. In partial agreement with the results of Experiment 2, in which the generation of likely sentences produced better recognition than did the generation of unlikely sentences, the more likely relationships had an advantage with Verbal generation, but only for Pictures [Likely, 90.9%; Unlikely, 82.2%; *t* (30) = 3.27]. For Words, the covert verbalization of relational sentences led to superior recognition of these nouns, whether or not the relationship was plausible.

Reported Strategies

Table 12, showing the reported usage of eight strategies and the correlation of usage and recall,

STIMULUS MODE:	Pictures		Words	
GENERATION TASK:	Imaginal	Verbal	Imaginal	Verbal
n:	(25)	(32)	(29)	(28)
CUED RECALL:	72	73	72	81
IMAGINAL:				
% Usage	12	8	29	27
Usage-Recall *r*	-.33	.02	-.23	-.34
IMAGINAL-RELATIONAL:				
% Usage	28	15	40	24
Usage-Recall *r*	.18	-.08	.19	.12
VERBAL:				
% Usage	7	12	8	6
Usage-Recall *r*	.04	-.01	-.22	.28
VERBAL-RELATIONAL:				
% Usage	10	9	1	4
Usage-Recall *r*	.01	-.17	.10	.16
IMAGINAL-VERBAL:				
% Usage	15	15	12	9
Usage-Recall *r*	-.12	.04	-.33	-.05
IMAGINAL-VERBAL-RELATIONAL:				
% Usage	24	36	10	28
Usage-Recall *r*	.09	.24	.27	.13
RELATIONAL:				
% Usage	3	4	0	0
Usage-Recall *r*	-.09	-.22	--	--
NONE:				
% Usage	1	1	0	1
Usage-Recall *r*	.06	-.37**	--	.13

Table 12. Percentage reported usage of eight strategies with imaginal generation and with verbal generation, and correlation of strategy usage with recall (Exp. 3).

** = $p < .01$

indicates several trends. Although participants reported a preponderance of I and I-R strategies when the task was explicitly imaginal (Pictures, 40%; Words, 69%) as well as when the verbal elaboration of words was required (51%), the correlation of this imagery with recall was either negligible or decidedly negative. Purely V and V-R strategies were rarely reported, even when instructions required such an approach, and except for Words, Verbal, in which the weak (.276) strategy-recall correlation is further weakened by the fact that it is based on only 6% reported usage, a verbal approach seems no more useful than an imaginal one. Even when the two approaches were combined in an I-V strategy, recall does not seem to have benefited. A pure relational strategy was almost never reported, so the R usage-recall correlational values are meaningless. The one approach that was both frequently claimed and for which the claim correlated positively with recall in all conditions is the mixed I-V-R strategy.

Table 13 simplifies the data of Table 12. Over all, forming images of the two objects (I, 82,7%) was reported to be much more prevalent [t (115) = 7.18] than was thinking of the relationship between them (R, 58.8%), which was reported to be more prevalent (t = 2.04) than was naming them (V, 52.1%). Task condition did not affect this reporting sequence. Subjects were apparently aware of I

STIMULUS MODE:	Pictures		Words	
GENERATION TASK:	Imaginal	Verbal	Imaginal	Verbal
n:	(25)	(32)	(29)	(28)
CUED RECALL:	72	73	72	81
IMAGINAL STRATEGY:				
% Usage	76	75	91	89
Usage-Recall *r*	-.01	.27	-.00	-.13
VERBAL STRATEGY:				
% Usage	59	70	30	49
Usage-Recall *r*	.03	.05	.01	.25
RELATIONAL STRATEGY:				
% Usage	62	64	51	58
Usage-Recall *r*	.25	-.01	.36*	.42**

Table 13. Percentage reported usage of three basic strategies for pictures and words with imaginal generation and with verbal generation, and correlation of strategy usage with recall (Exp. 3).

** = $p < .01$

and R processing to the same extent whether their orienting task was Imaginal (I, 84.2%; R, 56.5%) or Verbal (I, 81.3%; R, 60.9%), and the preference for I was as pronounced with a Verbal task [t (61) = 4.48] as with an Imaginal task [t

(54) = 5.72]. As would be expected, more V was reported by the Verbal than by the Imaginal groups [59.7% vs. 43.5%; t (57) = 3.45]. For the Verbal groups, equal reliance on R (60.9%) and on V (59.7%) was claimed, whereas for the Imaginal groups, significantly more R (56.5%) than V (43.5%) was claimed [t (54) = 2.70].

The nature of the stimuli had little effect on the strategy reported. Imagery was claimed more often than relational processing with both Pictures [I, 75.4%; R, 63.3; t (57) = 2.57] and Words [I, 89.8%; R, 54.5%; t (58) = 7.56], and even more I seems to have been experienced with Words than with Pictures (89.8% vs. 75.4%; t = 3.08). Conversely, much more V was reported for Pictures than for Words (64.8% vs. 39.6%; t = 5.37). More R was also reported for Pictures than for Words (63.3% vs. 54.5%; t = 1.87). That is, with Pictures, equal usage was claimed for R (63.3%) and V (64.8%), whereas with Words, more R than V was claimed (54.5% vs. 39.6%; t = 3.19).

In combining all strategies involving imagery, Table 13 clearly reveals the ineffectiveness of I. (With df = 23-30, the critical values for r are .337-.296 for a one-tailed test of positive correlation, or .396-.349, if inverse correlations are also considered.) The V strategy-recall correlations are equally feeble. However, two moderate but significant correlations did emerge in Experiment 3: a reliance on R strategies predicted recall

with verbal stimuli, regardless of the form of generation (Words, Imaginal, .362; Words, Verbal, .415).

Image Vividness and Sentence Likelihood Ratings

The question of whether it is the vividness with which images were experienced that determined recall is addressed by the correlations presented as "Rating-Recall r" in Table 14. The data for these correlations are the mean vividness rating of each subject in the Imagery conditions, or the mean sentence likelihood rating of each subject in the Verbal conditions, and that subject's percentage cued recall. A moderate but significant positive Vividness-Recall correlation did occur for Words (r = .397, df = 28). However, for Pictures, the Vividness-Recall correlation was weakly negative (r = -.112). Interestingly, an almost identical pattern occurred for the rated likelihood of the sentences generated in the Verbal conditions: a definite positive Likelihood-Recall correlation for Words (r = .416, df = 27) and a negative correlation for Pictures (r = -.116).

Looking at the correlations between task ratings (Image Vividness or Sentence Likelihood) and reported usage of the three basic strategies may clarify these results, since the finding that relationships rated highly vivid or likely were better recalled means little unless the process by which the ratings were determined is known. The

STIMULUS MODE:	Pictures		Words	
GENERATION TASK:	Image Rating	Sentence Rating	Image Rating	Sentence Rating
n:	(25)	(32)	(29)	(28)
CUED RECALL:	72	73	72	81
TASK RATING:	3.3	2.7	3.6	2.8
Rating-Recall *r*	-.11	.12	.40**	.42**
TASK-STRATEGY CORRELATION:				
Rating-Imaginal *r*	.01	.12	.28	.19
Rating-Verbal *r*	-.22	-.09	-.00	.51**
Rating-Relational *r*	.24	-.11	.25	.48**

Table 14. Ratings (1-5) of image vividness (imaginal generation task) and of sentence likelihood (verbal generation task) for pictures and words, and correlation of ratings with recall and with percentage reported usage of imaginal, verbal, and relational strategies (Exp. 3).

** = $p < .01$

question of interest is whether those who rated their word-induced elaborations as imaginally vivid (and who tended to recall more words than did those who gave lower vividness ratings to their elaborations) based these ratings on generated images. As the *r* values in Table 14 under "Task-Strategy Correlation" show, the answer seems to be "No."

The correlation of judged image Vividness and reported I usage is a nonsignificant .280 for Words and only .014 for Pictures. The correlations of judged sentence Likelihood and I usage are also unimpressive. In fact, task ratings and strategies correlated significantly only with verbal stimuli, a verbal task, and nonimaginal strategies. Among those who saw word pairs and generated sentences the rated Likelihood of these sentences was indicative of the reported usage of both V (r = .509) and R (r = .484).

Task-Task Correlations

Correlations between the ratings given each stimulus pair by the two Task groups, shown in Table 15, demonstrate the functional equivalence of the Imaginal and Verbal orientations. That is, relationships that produced an impression of visual vividness were the same relationships that were rated very likely to be expressed in sentences, and relationships that seemed more difficult to "visualize" were the same relationships that were rated less likely to be expressed in sentences. The correspondence between the two tasks was striking, regardless of mode of presentation (Pictures, r = .775; Words, r = .800; df = 38). It was especially close for the Likely relationships (Likely, r = .757, Unlikely, r = .616; df = 38) and closest when these relationships were conveyed by noun pairs (Words, Likely, r = .811; Pictures, Likely, r = .733; df = 18).

STIMULUS MODE:	Pictures	Words
VIVIDNESS-LIKELIHOOD CORRELATION:		
r (n = 40)	.78**	.80**
Likely Pairs r (n = 20)	.73**	.81**
Unlikely Pairs r (n = 20)	.68**	.58**

Table 15. Correlation of imaginal task ratings (vividness) with verbal task ratings (sentence likelihood) for generated relationships between likely and unlikely pairs of pictures and words (Exp. 3).

** = $p < .01$

Discussion of Experiment 3

Memory

Figure 3 provides a schematic representation of the recall results of Experiment 3 (from Table 11) in the lower graph, along with a reminder of the results of Experiments 1 and 2, shown on the upper left and right, respectively. The recall data of Experiment 3 provide three arguments for the principle of elaborative convergence. (1) They reaffirm the mnemonic equivalence of verbal and pictorial stimuli that was demonstrated by separate means in Experiments 1 and 2. (2) They confirm the mnemonic equivalence of a verbal and an imaginal task that was suggested by a comparison of the results of the first two

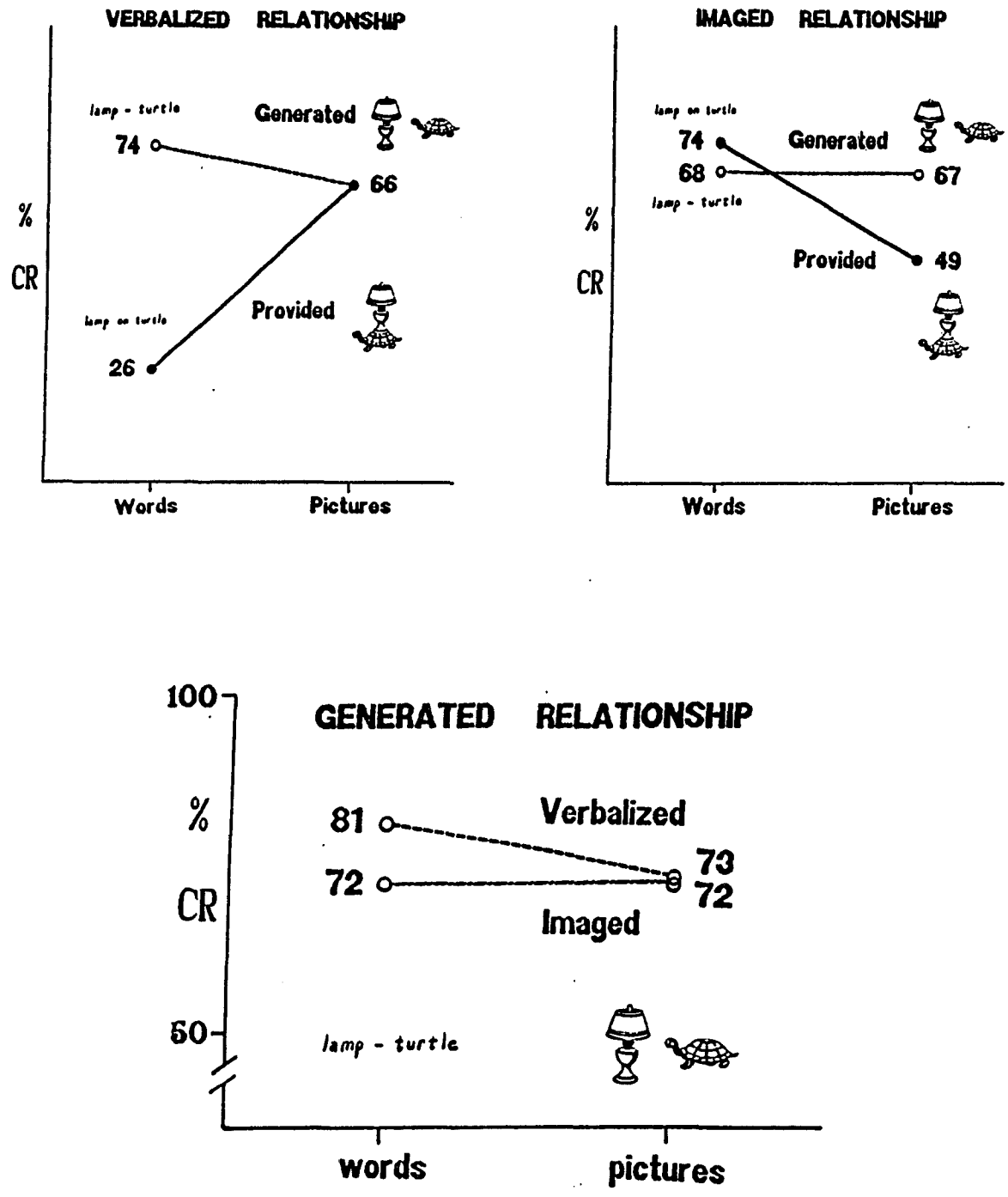

Figure 3. Percentage recall of pictures and words with verbal generation and with imaginal generation (Exp. 3) compared with results of comparable conditions (Exps. 1 and 2).

experiments. The demonstration that the two forms of generation can be equally effective suggests that their effectiveness may be due to a principle common to both. (3) The data also show that the effectiveness of both pictorial and verbal stimuli may be equalized by means of either a verbal or an imaginal task, disconfirming any special advantage for dual coding. This demonstration indicates that dual coding is not the reason for the generation effects in the cross-modal conditions of Experiments 1 and 2.

Recognition performance in Experiment 3, as in the high-recall conditions of Experiments 1 and 2, is quite accurate, indicating that the encoding process that made the target accessible to the cuing item did not compromise its integrity as as a distinct entity. That is, distinctive characteristics of each of the stimulus items were apparently automatically encoded, even though elaboration converged on the concept that related them.

The case for elaborative convergence is strengthened by two additional memory results of Experiment 3. (1) Like Experiments 1 and 2, Experiment 3 provides no support for the notion that bizarre associations, especially if imaged, are especially potent mnemonics. The generation of a familiar relationship between two nouns increased the probability that one would cue the other (relative to the

generation of an unfamiliar relationship). The advantage for pre-existing relationships, which would link target and cue more closely than would novel relationships, indicates the appropriate convergence of both the initial elaboration and the cuing process.

(2) Although the difference reached significance only in recognition, the most effective stimulus-task combination for both tests was, as in Experiment 1, separate noun pairs associated verbally. Since of the four generation conditions considered, this one was least conducive to the processing of extraneous perceptual information, this result is especially compatible with an account that stresses the quality of elaboration.

Strategies

As in Experiments 1 and 2, imagery, although evidently widely experienced in all conditions, either did not correlate with recall or correlated negatively. Only in conjunction with other strategies did imagery show even a weak positive correlation with recall, and then only with pictures and verbal generation. Although covert naming was not reported as a primary strategy in any condition, it apparently accompanied most processing, and became most prevalent with pictures, especially when verbal generation was required. However, the awareness of verbal associations, like the awareness of visual associations, was apparently irrelevant to recall, producing a weak

positive correlation only when both stimuli and task were in the verbal mode.

Relational processing was also reported in every condition, primarily as a concomitant of imagery. Nevertheless, its correlation with recall was weak for pictures related imaginally (and nonexistent for pictures related verbally). Relational thinking and recall did correlate significantly with noun-pair stimuli, and the correlation was highly significant for both verbal and imaginal generation. Although a correspondence between generation and relational processing might be considered consistent with the convergence interpretation of the generation effect, the overriding message of this research is that subjective reports are valueless. If not, this outcome should have appeared in the other two experiments.

Image Vividness and Sentence Likelihood

As always, the vividness ratings of images evoked by nouns correlated highly with recall. As predicted by a convergence account of imagery, however, the likelihood ratings of sentences generated from nouns also correlated highly with recall. Furthermore, the rating-recall correlations of picture-evoked images were slightly negative, and those of picture-evoked sentences were negligible. That is, verbal stimuli plus the process of generating a specified relational concept seemed to produce

impressions of specificity or familiarity, the strength of which correlated with recall; whether these impressions arose from an imaginal or verbal orientation was inconsequential.

Correlations between vividness or likelihood ratings and reported usage of the three basic stategies in each condition support this interpretation of the usual mnemonic advantage for vividly imaged material. If the vivid imagery reported by those with high recall scores were the reason for their superior memory, these students should be those who relied most heavily on an imaginal strategy. Yet there is little correlational evidence that the vividness ratings were actually based on generated images. In fact, "thinking of the relationship," seems to have been as good a basis as any for determining "vividness." Sentence likelihood ratings, in contrast, did correlate significantly with reported usage of both verbal and relational strategies.

One final set of correlations gives additional assurance to the conclusion that imagery is not the reason for the imagery effect. The agreement between image vividness ratings and sentence likelihood ratings for both picture and word pairs was remarkable. That is, a particular stimulus pairs was apt to receive the same rating on either task. The more memorable items--those encoded in a likely relationship--received the higher

ratings, regardless of task condition. To the extent that a relationship was considered perceptually vivid, a sentence expressing the relationship was considered likely, probably in response to the same processing dynamics.

Conclusions: The Mnemonic Value of Provided or Generated Words or Images

The major issue addressed in this study was the efficacy of two views of elaboration in predicting recall. Stimulus-based picture-superiority predictions and task-based imagery- and generation-effect predictions were compared with a qualitative, process-based view, convergence of elaboration. Three experiments investigated the effect on cued recall and recognition of both relatively passive processing and more generative processing with verbal and pictorial stimuli. Considered as a whole, the experiments demonstrate some previously neglected effects: Although pictures can be more effective than verbal descriptions in promoting cued recall (Experiment 1), with a different processing orientation the same verbal descriptions can promote recall more effectively than pictures (Experiment 2), and verbal and imaginal orienting tasks can be equally effective in promoting recall of either words or pictures (Experiment 3). Each of these outcomes was produced when

processing in one condition was directed more than in the other to the relationship between the stimulus items.

The Role of Task

Although subjective generation of the relationship was the means by which this directed processing was obtained in Experiment 3 and in half the conditions of Experiments 1 and 2, another unusual demonstration, that presented and generated information can be equally effective (with pictures in Experiment 1 and with words in Experiment 2), indicates that it was the focusing effect imposed by generation and not generation per se that improved cue effectiveness. Provided relationships were as effective as generated ones only if the orienting task directed elaborative processing to the relationship. Even when the relational information was pictorially provided, verbalizing it (Experiment 1) reduced attention to nonrelational attributes apparent in the picture, promoting integration equal to that produced when the relationship was generated. In contrast, interactive pictures were ineffective stimuli when an imaginal task encouraged unfocused processing (Experiment 2).

Similarly, by directing elaboration to perceptual features of the relationship expressed, an imaginal task boosted the effectiveness of preposition-linked nouns to the level attained when the relationship was generated (Experiment 2). The same noun phrases were ineffective

stimuli when a verbal task encouraged diffuse associative processing of the concept (Experiment 1). These earlier findings indicate that the uniformly high recall demonstrated when all conditions required generation of a relational concept (Experiment 3) could not be attributed solely to verbal or imaginal generation.

It might still be argued that generation in a broader sense was the operative factor in all cases of relatively high retrieval. In both experiments, relationship-provided conditions produced good recall only with a cross-modal task--i.e., only when the required response was to some degree generated. However, if this point is conceded, then those who raise it must concede that the generation of a concept not provided by the stimulus is not essential for a "generation effect." However one defines generation, the findings presented support the hypothesis that its effectiveness results from the focus that it imposes on semantic elaboration rather than from the absence of the elaborated concept from the stimulus or the presence of a particular conscious product of the elaboration, whether words or images.

Taken as a whole, the three experiments indicated that any relevance to memory of imagery derived from the relational processing that underlay this conscious experience. A significant correlation between reported

imagery and recall occurred only with a verbally provided task when the orienting task was explicitly imaginal and only with a verbally provided concept (Experiment 2), even though imagery was reported to be the predominant accompaniment of generation in every experiment. With a pictorially provided concept, it was covert verbalization that correlated with recall (but also only during the image-production task, Experiment 2).

The only evidence from a generative task of the relevance of conscious thought to later memory were two significant correlations between relational thinking and recall when the stimuli were separate words. No conclusions are justified by this result, however, since it occurred only in Experiment 3.

Although the strategy data are poor predictors of relative retrieval, they do generally accord with common sense. For example, in the picture conditions of all three experiments more verbal than relational processing was reported when relationships were provided, but more relational than verbal processing was reported when relationships were generated. Whether such reports have any validity or simply indicate subject compliance with expectations is arguable.

The Role of Stimuli

In no case was there an advantage for externally organized, interactive stimuli over separate pairs in the

same mode. In fact, when the external events were elaborated by relational knowledge, separate word pairs were more effective than coherent phrases (Experiment 1), and separate picture pairs were more effective than interactive pictures (Experiment 2).

A final outcome which some might think unusual occurred in all conditions in all three experiments. Targets in plausible relationships were better recalled than targets in less plausible relationships. This research was not designed to challenge the bizarreness effect, although this effect is inconsistent with a principle extolling the benefits of conceptual coherence. Nevertheless, there is increasing evidence against the popular idea that bizarre images or associations are particularly good mnemonic devices (e.g., Einstein & McDaniel, 1987; Martin, 1985). To the extent that experimenter-provided bizarreness aids memory, it seems to do so only with mixed lists of bizarre and common relationships, only for short retention intervals, and only for free recall (McDaniel & Einstein, 1986). In other words, except insofar as they temporarily enhance the retrieval of some list items relative to others, unlikely pairings seem to be weak pairings. Apparently even stimulus-task combinations which promote convergent elaboration are less effective when the relationship

considered contravenes the existing associative network.

Questions for Further Study

Since the convergence appropriate to paired-associate learning is that which integrates the cue and the target items, convergence effects were predicted only in cued recall. Yet in Experiments 1 and 2, recognition accuracy dropped when cued recall was poor (when sentences had been generated from telegraphic phrases and when images had been generated from interactive pictures). This similarity in recall and recognition performance suggests that processing which benefited relational processing also benefited the separate items and that nonrelational processing failed to benefit the separate items. In other words, as elaboration of the pair converged on a unitary concept, either item became an effective retrieval cue--in cued recall, for the other component, and in recognition, for itself.

The unexpected extension of the recall results to recognition may have been due to the nature of the recognition test. Perhaps it would not have occurred had the stimulus pairs as originally shown been provided for recognition, instead of the target terms only. Even though the relational concept was not especially salient in these conditions, the poorly recognized items had presumably been encoded in the form in which they were presented--as participants in an interactive situation. Certainly, the same discrepancy between presentation and recognition

stimuli occurred in a high-recognition condition in both Experiments 1 and Experiment 2, but in those conditions the cross-modal generation involved (in stating the interaction in pictures and imagining the interaction in phrases) focused processing on the relational concept. Nevertheless, the correspondence between recall and recognition patterns raises questions that must be addressed in refining the convergence interpretation of memory effects.

Together, the three experiments demonstrate that supposed picture superiority, imagery, generation, and even organization effects are not absolute. Word and picture pairs can promote equal recall when processing involves the elaboration of a relationship between the elements; verbal and imaginal tasks can promote equal recall when both involve this relational elaboration; provided and generated relationships can promote equal recall when the combination of stimulus mode and processing orientation directs processing to the relationship. The findings of the first two experiments indicate that the uniformly high recall demonstrated in Experiment 3 for words and pictures with verbal or imaginal generation cannot be due to stimulus or task alone. It can most reasonably be attributed to elaborative convergence, the only factor consistently associated with higher retrieval in every procedure.

CHAPTER III

GENERAL DISCUSSION: CONVERGENT ELABORATION AND REPRESENTATION

Memory as Structure

Dual Representation

Both the picture superiority effect and the benefits conferred by image formation are customarily cited as confirmation of Paivio's dual coding theory. According to Paivio (1971), verbal information is organized primarily in a sequential form, nonverbal information in an analogue form. In addition to this direct encoding, words may evoke visual images and pictures may be labeled, so either form of input may also be coded in, and indirectly accessed from, the contramodal system. On the premise that two codes produce better memory than one, dual coding theory predicts an advantage for words that readily evoke visual images, relative to more abstract terms, and for pictures that readily evoke verbal labels, relative to more ambiguous spatial arrays.

Although dual representation is sufficient to explain the advantage of mentally visualizing objects that are named and mentally naming objects that are pictured, an additional premise is needed to explain the absolute

advantage of pictures over words. Paivio (1971) proposed that pictures are more likely to evoke labels than are labels to evoke images. Accordingly, the picture of a familiar object, like the object itself, should be virtually certain to excite representations in both coding systems. A name, when it occurred in the absence of a concrete referent, might be registered only verbally.

The faster and more reliable crossover to the contramodal system for pictures than for words hypothesized by dual coding theory presumably reflects the relative automaticity of the two processes. That is, the theory implies that the parallel processing of spatial information is developmentally or evolutionarily more fundamental than the serial processing of language. So if generating the name of a pictured object is more certain than is generating an image of a named oject, it follows that the ability to name pictures should be less subject to individual differences than the ability to imagine the referents of words.

This implication of dual coding seems to be valid. Scores on tests of verbal memory tend to correlate with scores on tests of imagery ability and with introspective reports on imagery use, which vary widely (Paivio, 1971). Some adults report no strategic use of imagery at all. Dual coding theory therefore supposes the dual

representation of a stimulus word, even one rated highly imageable, to be problematic, depending on both the time available for image formation and the individual's propensity to process language imaginally.

The Problem with Dual Representation

The weakness of dual coding theory is that it can claim credit for too many results. For example, since it assumes that a generated image and a presented picture enhance memory by the same process (Paivio, 1971), dual coding makes no clear prediction about the relative effectiveness for words and pictures of an imaginal strategy. In accordance with the premise that two codes are preferable to one, words plus imagery should produce better recall than pictures plus imagery. However, in accordance with the premise that pictures also enjoy an absolute advantage over words, the picture superiority effect might prevail, even when imagery is generated in both conditions. Alternatively, the picture and imagery effects might cancel each other, producing equal recall in the two stimulus modalities.

The relative mnemonic value of pictures and words with an imaginal orienting task is not the only point on which dual coding theory is noncommittal. Since it maintains that mediational imagery is effective as either a deliberate strategy or a spontaneous accompaniment of verbal mediation (Paivio, 1971), it is also equivocal about

the relative value of verbal and imaginal generation. Dual coding theory does, however, allow predictions about the value of provided and generated information within a stimulus modality.

If all imagery is just imagery, pictures of interacting objects and images of interactions between objects should be equally beneficial to memory. By the same reasoning, images of interactions should be equally helpful, whether evoked by a phrase relating two concrete nouns or by the verbal generation of this relationship. It is on these two comparisons that dual-coding predictions can be tested against an amodal alternative, predictions based on a generation advantage. (Neither model wins, as the reported study indicates, because the predictions of either can be confirmed or disconfirmed, depending on the combined effects of stimulus modality and orienting task.)

Kieras (1978) criticized the dual-coding account of memory for verbal material in terms of differential imageability on the grounds that it fails to address the role of processes such as perception, comprehension, and the deliberate manipulation of images. He contended that Paivio's theory treats memory as the repository of raw sensory data--words and visual displays--rather than as the semantic system of concepts, properties, and relations that computer simulations indicate it must be.

Physiological evidence that image generation is not an exclusively right-hemispheric process (Kosslyn, Holtzman, Farah, & Gazzaniga, 1985) and that either hemisphere may be more active during the processing of either verbal or visual material, depending on whether the analysis is global or analytic (Gazzaniga & Hillyard, 1971; Ross & Turkewitz, 1982) provides further reason to discard a rigid distinction between verbal and nonverbal codes.

Amodal Representation

Opposing the idea of separate visual and verbal systems is the view that processing and representation are independent of the input mode. According to this view, information is stored in a propositional form that preserves its significant aspects but not necessarily the sensory code in which it arrived. Proponents of an amodal system consider comprehension a process that is both reductive and constructive. It involves extracting salient aspects of the input from the sensory particulars and elaborating the extracted information with knowledge acquired from similar input. The representations thus derived are less copies of reality than abstract relational meanings integrated in an organized system of meanings.

The Problem with Amodal Representation

Propositional models are more compatible than stimulus-bound models such as dual coding with evidence that memory is nonveridical and mutable. They are

particularly successful in explaining the associative and inferential processing of verbal input. However, a propositional account seems less applicable to the effects of nonverbal processing. Neither an advantage of pictures over words nor an advantage of an imaginal over a verbal processing strategy is an obvious consequence of an amodal system. In attempting to apply this system to these effects, its proponents have offered only differential elaboration as an alternative to dual coding (Anderson, 1980; Anderson & Reder, 1979). Yet since even these proponents acknowledge that due to its irrelevant fan, elaboration may sometimes depress recall rather than enhance it (Anderson, 1983), and since no objective criterion has been proposed to predict the outcome of elaboration, the elaboration hypothesis has been even less testable than the dual coding hypothesis. Rated imageability has at least proved consistently predictive of recall (Paivio, 1971).

Memory as Process

Removing the Distinction Between Dual and Amodal Coding

The mnemonic superiority of pictured objects to their labels and of imaginal to verbal strategies is customarily cited as evidence of the additive effects of separately

processed visual and verbal representations, whereas the superiority of internally generated to externally provided words has been considered more compatible with an amodal system. Because memory research tends to proceed within the confines of a particular theoretical camp, the findings emphasized by one researcher may seem of little relevance to another. Certain effects have therefore been compartmentalized by theory, and the investigation of possible correspondences among them is rare.

Yet as Anderson (1978) has argued, none of the evidence offered in support of either dual coding theory or propositional models precludes the other view. It may be precisely in comparing the effects emphasized by seemingly opposing accounts--especially those effects that are not readily assimilable by the other--that cognitive psychology may discover significant truths about memory.

Regardless of the validity of the criticisms leveled against dual coding as a representational model, to abandon the idea of complementary serial and analogue processing modes would be equivalent to rejecting the theory of natural selection on the grounds that it fails to specify the mechanisms of genetic transmission. The theory of dual coding was not developed to explain the transformation of verbal and visual codes into complex and interrelated meanings. Paivio proposed it in 1971 as an alternative to the then-prevalent view that thought is an exclusively

verbal, sequential process. Today, Paivio and others continue to address the issues raised by propositional theorists and to develop the dual-coding model (e.g., Paivio, 1986), which seems broad enough to accommodate new findings. Its merit is its attention to the powerful mnemonic effects of pictorial stimuli and imaginal processing--effects that the propositional models have so far neglected.

Dual coding theory posits three stages of processing for meaning: representational, referential, and associative. According to Paivio (1971), beyond the representational stage of initial modality-specific registration, at the referential and associative levels, verbally and visually acquired knowledge both contribute to the comprehension of stimuli presented in either mode. That is, mechanisms for modality-independent semantic processing are fundamental to the theory.

As Marschark, Richman, Yuille, and Hunt (1987) have pointed out, separate forms of early processing do not necessitate separate long-term storage systems. Both visually and verbally received information may be retained in amodal configurations from which it may be redintegrated as either imagery or speech. By giving equal status to equivalent knowledge from differing sources, this resolution would allow dual coding theory to account for

the salutory effect of verbal as well as imaginal generation.

Although the generation effect is usually discussed in a propositional framework, it is the hypothesized associative organization of such a system rather than its amodal nature that seems relevant to the effect. Although the generation effect can not be explained by reference to the advantage of dual representation, it is not inconsistent with dual perceptual modes that are separately specialized for analytic and global processing. It is clearly consistent with discrete processes of verbal and imaginal generation.

The propositional view of representation in principle encompasses nonverbally acquired knowledge. In experimental practice, however, it has underemphasized the importance of such knowledge in human associative memory. Still, the inherent flexibility of an amodal system should allow it to improve its balance. Kosslyn has recommended that two types of proposition be admitted, one storing knowledge that is decodable into declarative sentences, the other representing spatial coordinates that are decodable into images (Kosslyn, Brunn, Cave, & Wallach, 1984; Kosslyn, Pinker, Smith, & Shwartz, 1979). This model would maintain the essential advantage of a propositional account, its suitability for computer simulation, while freeing it from its lexical bias.

The convergence account of memory effects advocated in this thesis does not require either a bimodal or an amodal model of representation. Either model could accommodate its propositions that visual detail and verbal context are equivalent in information value, that the usefulness of either provided or generated information depends on the precision of its relationship with a target response, and that image formation and verbal production are alternative means of expressing this relational processing. The principle of convergent elaboration does not specify the nature of representation because it pertains to the application of an inherently flexible semantic organization to variable memory requirements. In fact, by locating memory effects in processing rather than in stimulus differences, the principle of convergent elaboration may help to reconcile the two positions.

The Process of Convergence

A convergence account of the mnemonic value of elaborative processing is consistent with the view that concepts are not so much represented in a static associative network as defined at each instance by patterns of concurrent activation. In normal reality, every event occurs in a rich perceptual and situational context, the features of which contribute to the processing pattern by which the event is interpreted. Since reality seldom if

ever repeats itself, the pattern associated with any concept would vary with each instance. The processing of a given event would either converge on, or diverge from, any particular subset of associations.

Unless the context of an event were exclusively and invariably associated with that event, the activation evoked would diverge somewhat from a prototypical pattern. It might involve some associations typical of a particular concept, but it would also involve associations typical of other concepts. The greater the distinctiveness, or mutual specificity, of the event and its context, the more likely that activation would converge on a prototypical conceptual pattern and the more likely the conscious accessing of this concept would become. In such a dynamic system, the probability that a cue from a prior encoding context would access a target pattern would depend on the extent to which the prior activation converged exclusively on this pattern.

The consciousness of imagery, like consciousness itself, may be an epiphenomenal result of this automatic interpretive process. To the extent that the processing of input is continuous, consciousness is continuous and thus may seem to direct imaginal elaboration. However, to conceive of this elaboration, which is the ongoing modification of the contents of consciousness, as the result of an intention which is itself a part of the contents of consciousness is teleological. It is not

necessary to posit an inner eye or conscious computational system, the function of which is to extract meaning from a phenomenal display which has already been meaningfully assembled by nonconscious processes.

The feeling of comprehension that accompanies attention to verbal input may result from the augmented activation produced by the convergence of the processing of incoming and of prior words, and the impression of imagery that accompanies the feeling of comprehension may be the perceptual aspect of this associative convergence. Thus the clarity of spontaneous imagery may directly indicate the extent to which the input is integrated with the representational system. That is, the image-evoking power, or concreteness, of a word may indicate the frequency with which it has been associated with particular physical features, and the concreteness of an extended description may indicate the frequency with which the perceptual features evoked by the words have been contextually associated.

Elaborative convergence may be necessary for the integral representation of stimulus elements, but integral representation is not of itself sufficient for retrieval. In order to account for the process of accessing the original elements of a unified concept as well as for the prior process of unification, the convergence principle

must apply to the retrieval cue. The processing view of memory has a clear criterion for cue effectiveness: a cue will promote retrieval to the extent that it reinstates the original encoding process (Tulving and Thomson, 1973).

In paired-associate learning, the paradigmatic case of relational elaboration, the cue is one of a pair of items associated during encoding. According, it should be particularly apt to reinstate the processing by which it was associated with the other item and thereby to access this item. Nevertheless, this cue is often ineffective--not necessarily because it failed to reinstate the encoding process but possibly because the encoding itself diverged from the relational concept.

If context constrains activation, the activation evoked by a compound event, such as two objects linked by a verb or a preposition, would be more constrained than the activation evoked by simultaneously occurring but unrelated objects. Therefore the imagery experienced should be more conceptually associated or instantiated than for randomly paired words. In general, as verbal input was clarified through contextual information, activation, and therefore imagery, would become more constrained. The more constrained the activation during comprehension, the more likely it would be that reactivation of the original traces by a component of the original event would be experienced as remembering the event.

This account would explain the mnemonic effects considered in this proposal without imputing special powers to either imagery or generation. The picture superiority effect, the imagery effect, and the generation effect (including the effect of generated images) may all result from elaborative processing that promotes the convergence of processing on the to-be-tested concept. If the stimuli or task conditions compared did not affect convergence differentially, these effects would not occur.

In the experiments reported in Chapter II, retrieval cues were effective when generation of the relationship was required, promoting the integration of cue and target. The cues were equally successful whether the generation task had been explicit (verbalizing or imaging a nonpresented relationship) or implicit (verbalizing a pictured relationship or imaging a stated relationship). Cue and target were less likely to be effectively integrated in the less generative conditions (verbalizing a stated relationship or imaging a pictured relationship). However, unless the relationship was a likely one, even generating it did not ensure the appropriate convergence of elaboration.

In summary, no single form of elaboration is most conducive to retrieval. Convergent elaboration can be induced externally or internally and it can involve

spatial, temporal, or functional associations. A processing pattern that converges on one meaning will diverge from another, making some recall cues more effective than others in accessing a predefined target. Whether the external stimuli and the internal processing orientation together promote memory will depend on the specificity with which they constrain elaboration to the learning to be tested.

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APPENDIX A

Please rate the likelihood of each relationship, using the following scale:

very unlikely 1 2 3 4 5 6 7 very likely

spoon in mitten	____	axe in drum	____
ball on seal	____	whip in vase	____
anchor on train	____	thermometer in tweezers	____
flag on fence	____	cook on camel	____
shovel in wheel	____	badge on gun	____
saddle on peacock	____	goggles on broom	____
kitten on package	____	ambulance on tracks	____
thermos in vest	____	fish in crib	____
necklace on purse	____	iron on lightbulb	____
whale on chimney	____	clown on banana	____
hen on ladder	____	baby in flowers	____
lamp on turtle	____	scissors in waffle	____
web on branch	____	horseshoe on penguin	____
bus on igloo	____	squirrel on sink	____
fan on chair	____	hatchet in belt	____
spider on guitar	____	jacket on fishhook	____
mop on sailboat	____	bee on globe	____
tire in truck	____	funnel on moose	____
dog on bicycle	____	walrus in ring	____
wagon on stove	____	flask on horse	____
eagle on propeller	____	windmill in snake	____

APPENDIX B

Presentation Order with Likelihood Rating Means
(7-point scale, n = 108)

	List 1	Rating	List 2	Rating
1.	whip in vase	1.5	shovel in wheel	1.6
2.	necklace on purse	3.0	bee on globe	3.1
3.	spoon in mitten	2.7	jacket on fishhok	2.6
4.	fish in crib	1.8	anchor on train	1.8
5.	thermos in vest	4.1	flag on fence	4.1
6.	whale on chimney	1.1	windmill in snake	1.1
7.	ambulance on tracks	2.7	cook on camel	2.7
8.	ball on seal	2.2	mop on sailboat	2.2
9.	tire in truck	6.3	web on branch	6.2
10.	lamp on turtle	1.3	iron on lightbulb	1.3
11.	spider on guitar	4.0	baby in flowers	3.6
12.	eagle on propeller	1.7	axe in drum	1.7
13.	goggles on broom	1.5	thermometer in tweezers	1.5
14.	dog on bicycle	2.1	badge on gun	2.2
15.	hatchet in belt	3.3	clown on banana	3.2
16.	bus on igloo	1.2	horseshoe on penguin	1.2
17.	saddle on peacock	1.4	funnel on moose	1.4
18.	squirrel on sink	2.4	hen on ladder	2.6
19.	scissors in waffle	1.4	wagon on stove	1.3
20.	kitten on package	4.2	fan on chair	4.7
	Means (Likely, 3.8; Unlikely, 1.5)	2.6	(Likely, 3.8; Unlikely, 1.5)	2.6

APPENDIX C

hatchet - belt

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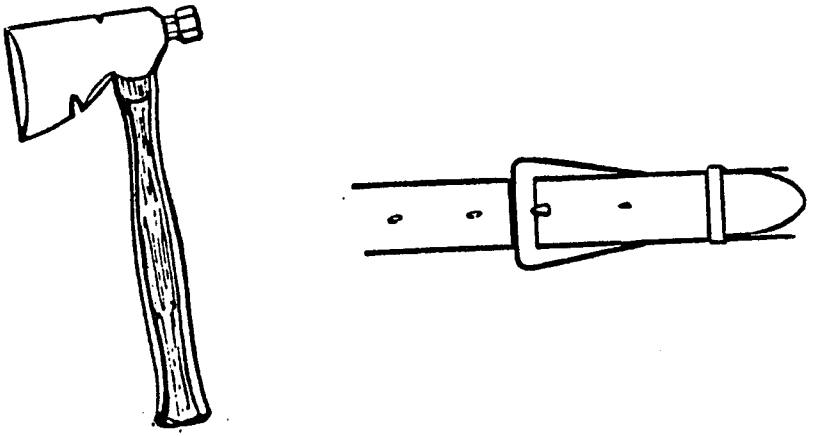
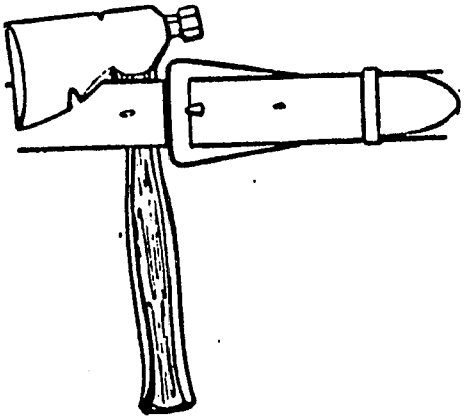
hatchet in belt





lamp - turtle

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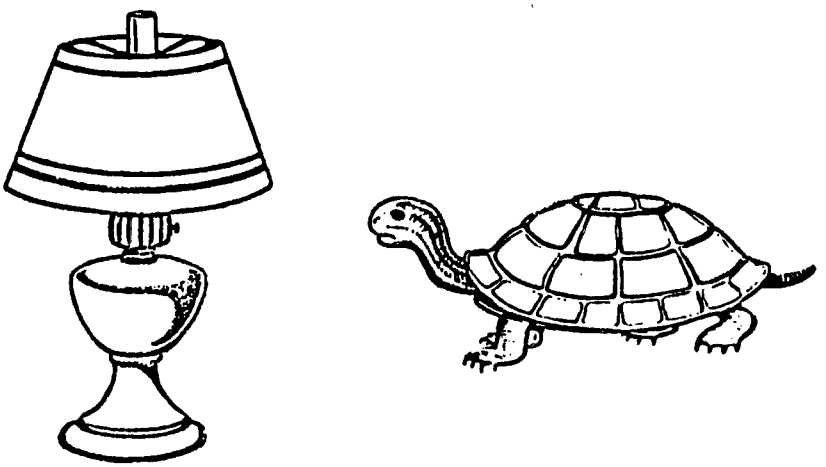
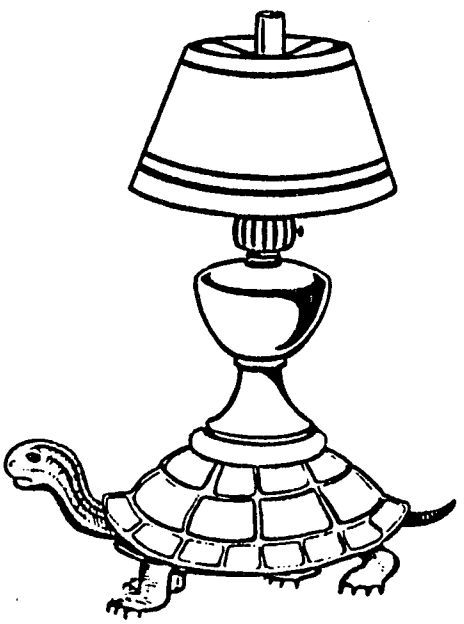
lamp on turtle





baby - flowers

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baby in flowers

wagon - stove

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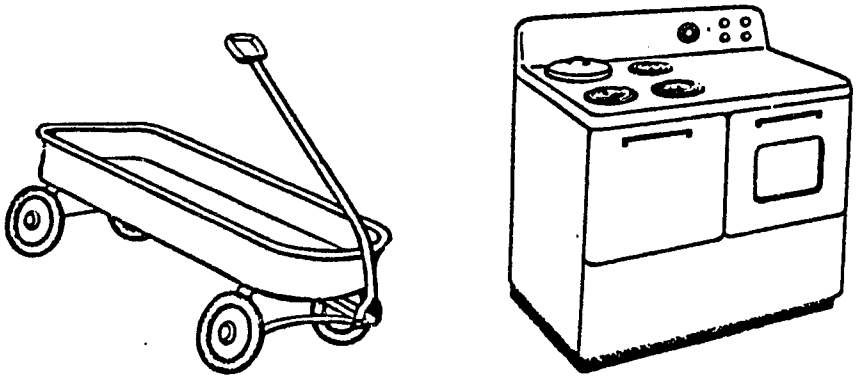
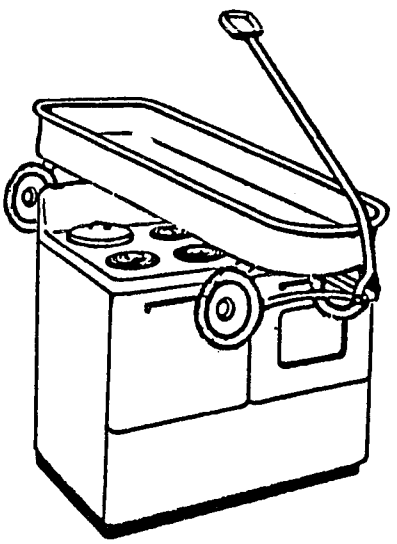
wagon on stove





APPENDIX D

Instructions, Experiment 1: Relationship Provided (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out how easily these items can be described.

A series of [three-word phrases / pictures] will appear on the video screen. Each [phrase relates the names of two objects with the word in or on / picture shows two objects, with one of them in or on the other].

Your task is to describe this relationship in one of these two sentences (INDICATE SIGN), substituting the [name / most common name] of each object for the X and Y. As soon as the [phrase / picture] disappears from the screen, I'd like you to say this sentence aloud. It is important that you say a sentence for every [phrase / picture]. Your responses will be recorded; just speak as loudly as you would to me.

The [phrase / picture] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next [phrase / picture] appears, a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Do you have any questions? ...

I'll begin by showing you 4 practice [phrases / pictures], so that you can get a better idea of the procedure. Please [read each of these phrases / think of the most common name of each object] so that you can say the appropriate sentence when the [phrase / picture] disappears. Are you ready?

(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Do you feel comfortable with the task? ...

During the rest of the procedure I'll leave you alone so that you can concentrate on the task. Just do your best to transform every [phrase / picture] into a sentence; then say the sentence aloud while the screen is blank.

(START TAPE RECORDER; START VIDEO; LEAVE ROOM, TAKING REMOTE CONTROL SWITCH; 20 TRIALS ... STOP VIDEO & RETURN)

Instructions, Experiment 1: Relationship Generated (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out what kind of relationship people prefer between different kinds of objects.

A series of pairs of [words / pictures] will appear on the video screen. Each pair [names / shows] two objects.

Your task is to decide which of these two sentences (INDICATE SIGN) could better express a relationship between these objects, substituting the [name / most common name] of each object for the X and Y. The sentence would describe the object [named / shown] on the left of the screen as either in or on the one [named / shown] on the right. The relationship you choose could be an ordinary one or it could be a very unlikely one, but you should have a reason for choosing it. So try to choose the more appropriate sentence - the one that relates the object on the left to the one on the right in a more meaningful way. (EXAMPLE, WORDS OR PICTURES RUG & BUG ON BOARD: "The rug is on/in the bug.")

As soon as the [words / pictures] disappear from the screen, I'd like you to say the sentence that you prefer aloud. It is important that you say a sentence for every pair of [words / pictures]. Your responses will be

recorded; just speak as loudly as you would to me.

The [words / pictures] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next pair of objects are [named / shown], a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Do you have any questions? ...

I'll begin by showing you 4 practice pairs, so that you can get a better idea of the procedure. Please decide whether the object on the left should be in or on the one on the right, so that you can say the appropriate sentence when the [words / pictures] disappear. Are you ready?
(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Do you feel comfortable with the task? ...

During the rest of the procedure I'll leave you alone so that you can concentrate on the task. Just do your best to choose the most appropriate sentence for every pair of [words / pictures]; then say the sentence aloud while the screen is blank.
(START TAPE RECORDER; START VIDEO; LEAVE ROOM, TAKING REMOTE CONTROL SWITCH; 20 TRIALS ... STOP VIDEO & RETURN)

The X is on the Y.

The X is in the Y.

Instructions, Experiment 2: Relationship Provided (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out how easily these items can be visualized.

A series of [three-word phrases / pictures] will appear on the video screen. Each [phrase relates the names of two objects with the word in or on / picture shows two objects, with one of them in or on the other].

Your task is to [form a visual image of this relationship / keep the image of this relationship in mind for a short time when it is no longer visible on the screen]. Notice that your answer sheet has a series of rating scales, each numbered from 1 to 5. For every [phrase / picture], I'd like you to circle a number to rate the vividness of [your image / the image you are holding when you look away from the screen]--that is, how vividly you visualize the relationship [described by the phrase / pictured. If the image you [experienced / retained] were very vague, you would circle 1. If it were very vivid, you would circle 5, and for intermediate degrees of vividness, you would circle 2, 3, or 4. It is important that you visualize every relationship.

The [phrase / picture] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next [phrase / picture] appears, a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Are there any questions? ...

I'll begin by showing you 4 practice [phrases / pictures], so that you can get a better idea of the procedure. Please [form a / retain the] visual image of each picture so that you can rate this image. Use the four practice rating scales at the top of the page. Are you ready?

(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Does everyone feel comfortable with the task? ...

During the rest of the procedure I'd like you not to communicate with each other and to be as silent as possible. Just do your best to [form an / hold the] image of every relationship and to rate every image honestly. You'll start with rating scale number 1 and work down the page. Here we go.

(START VIDEO; 20 TRIALS ... STOP VIDEO)

Instructions, Experiment 2: Relationship Generated (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out how easily these items can be visualized in relation to each other.

A series of pairs of [words / pictures] will appear on the video screen. Each pair [names / shows] two objects.

Your task is to form a visual image that relates these objects so that the one [named / shown] on the left of the screen in <u>in</u> or <u>on</u> the one [named / shown] on the right. The relationship you visualize could be an ordinary one or it could be a very unlikely one, but you should form as vivid an image as possible of the object on the left either in or on the one on the right.

(EXAMPLE, WORDS OR PICTURES <u>RUG</u> & <u>BUG</u> ON BOARD: "Visualize a rug <u>on</u>/<u>in</u> a bug.")

Notice that your answer sheet has a series of rating scales, each numbered from 1 to 5. For every pair of objects, I'd like you to circle a number to rate the vividness of your image--that is, how vividly you visualize the relationship between the objects. If the image you experienced were very vague, you would circle 1. If it were very vivid, you would circle 5, and for intermediate degrees of vividness, you would circle 2, 3, or 4. It is

important that you visualize a relationship between every pair of objects.

The [words / pictures] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next pair of objects are [named / shown], a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Are there any questions? ...

I'll begin by showing you 4 practice pairs, so that you can get a better idea of the procedure. Please form a visual image of each pair of objects, with the one on the left <u>in</u> or <u>on</u> the one on the right, so that you can rate this image. Use the four practice rating scales at the top of the page. Are you ready?

(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Does everyone feel comfortable with the task? ...

During the rest of the procedure I'd like you not to communicate with each other and to be as silent as possible. Just do your best to form an image relating every pair of [words / pictures] and to rate every image honestly. You'll start with rating scale number 1 and work down the page. Here we go.

(START VIDEO; 20 TRIALS ... STOP VIDEO)

Instructions, Experiment 3: Imaginal Generation (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out how easily these items can be visualized in relation to each other.

A series of pairs of [words / pictures] will appear on the video screen. Each pair [names / shows] two objects.

Your task is to form a visual image that relates these objects so that the one [named / shown] on the left of the screen in <u>on</u> the one [named / shown] on the right. The relationship you visualize could be an ordinary one or it could be a very unlikely one, but you should form as vivid an image as possible of the object on the left on top of the one on the right.

(EXAMPLE, WORDS OR PICTURES <u>RUG</u> & <u>BUG</u> ON BOARD: "Visualize a rug on a bug.")

Notice that your answer sheet has a series of rating scales, each numbered from 1 to 5. For every pair of objects, I'd like you to circle a number to rate the vividness of your image--that is, how vividly you visualize the relationship between the objects. If the image you experienced were very vague, you would circle 1. If it were very vivid, you would circle 5, and for intermediate degrees of vividness, you would circle 2, 3, or 4. It is

important that you visualize the relationship between every pair of objects.

The [words / pictures] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next pair of objects are [named / shown], a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Are there any questions? ...

I'll begin by showing you 4 practice pairs, so that you can get a better idea of the procedure. Please form a visual image of each pair of objects, with the one on the left on the one on the right, so that you can rate this image. Use the four practice rating scales at the top of the page. Are you ready?

(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Does everyone feel comfortable with the task? ...

During the rest of the procedure I'd like you not to communicate with each other and to be as silent as possible. Just do your best to form an image relating every pair of [words / pictures] and to rate every image honestly. You'll start with rating scale number 1 and work down the page. Here we go.

(START VIDEO; 20 TRIALS ... STOP VIDEO)

Instructions, Experiment 3: Verbal Generation (Word and Picture Stimuli, Respectively)

The purpose of this study is to collect information about some stimulus items that will be used in a later experiment. We want to find out how likely certain kinds of statements are, in your judgment.

A series of pairs of [words / pictures] will appear on the video screen. Each pair [names / shows] two objects.

Your task is to think of a sentence that describes the object [named / shown] on the left of the screen as <u>on</u> the one [named / shown] on the right. The sentence should take the form "The <u>X</u> is on the <u>Y</u>, substituting the [name / most common name] of each object for the <u>X</u> and <u>Y</u>. (EXAMPLE, WORDS OR PICTURES <u>RUG</u> & <u>BUG</u> ON BOARD: You would mentally construct the sentence "The rug is on the bug.")

Notice that your answer sheet has a series of rating scales, each numbered from 1 to 5. For every sentence you construct, I'd like you to circle a number to rate its likelihood--that is, how likely this particular sentence is to occur in speech or in print. If the sentence were very unlikely, you would circle 1. If it were very likely, you would circle 5, and for intermediate degrees of likelihood, you would circle 2, 3, or 4. You should not say the sentence aloud, but it is important that you keep the complete sentence in mind as you do the rating.

The [words / pictures] will remain on the screen for 4 seconds, and then the screen will be blank for 6 seconds. Two seconds before the next pair of objects are [named / shown], a row of stars will appear on the screen. When the stars appear, you should be watching the screen. Are there any questions? ...

I'll begin by showing you 4 practice pairs, so that you can get a better idea of the procedure. Please insert the names of each pair of objects in a sentence of the form "The X is on the Y, with the one on the left on the one on the right, so that you can rate this sentence. Use the four practice rating scales at the top of the page. Are you ready?

(DIM LIGHTS; START VIDEO; 4 TRAINING TRIALS; STOP VIDEO)

Does everyone feel comfortable with the task? ...

During the rest of the procedure I'd like you not to communicate with each other and to be as silent as possible. Just do your best to construct a complete sentence of the proper form for every pair of [words / pictures] and to rate every sentence honestly. You'll start with rating scale number 1 and work down the page. Here we go.

(START VIDEO; 20 TRIALS ... STOP VIDEO)

APPENDIX E

Name _____ .

Practice Trials

(very vague) P1. 1 2 3 4 5 (very vivid) (very vague) P3. 1 2 3 4 5 (very vivid)

(very vague) P2. 1 2 3 4 5 (very vivid) (very vague) P4. 1 2 3 4 5 (very vivid)

---

1. 1 2 3 4 5
2. 1 2 3 4 5
3. 1 2 3 4 5
4. 1 2 3 4 5
5. 1 2 3 4 5
6. 1 2 3 4 5
7. 1 2 3 4 5
8. 1 2 3 4 5
9. 1 2 3 4 5
10. 1 2 3 4 5
11. 1 2 3 4 5
12. 1 2 3 4 5
13. 1 2 3 4 5
14. 1 2 3 4 5
15. 1 2 3 4 5
16. 1 2 3 4 5
17. 1 2 3 4 5
18. 1 2 3 4 5
19. 1 2 3 4 5
20. 1 2 3 4 5
21. 1 2 3 4 5
22. 1 2 3 4 5
23. 1 2 3 4 5
24. 1 2 3 4 5
25. 1 2 3 4 5
26. 1 2 3 4 5
27. 1 2 3 4 5
28. 1 2 3 4 5
29. 1 2 3 4 5
30. 1 2 3 4 5

Name _____

Practice Trials

(unlikely) _____ (likely)
P1. 1 2 3 4 5

(unlikely) _____ (likely)
P2. 1 2 3 4 5

(unlikely) _____ (likely)
P3. 1 2 3 4 5

(unlikely) _____ (likely)
P4. 1 2 3 4 5

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1. 1 2 3 4 5
2. 1 2 3 4 5
3. 1 2 3 4 5
4. 1 2 3 4 5
5. 1 2 3 4 5
6. 1 2 3 4 5
7. 1 2 3 4 5
8. 1 2 3 4 5
9. 1 2 3 4 5
10. 1 2 3 4 5
11. 1 2 3 4 5
12. 1 2 3 4 5
13. 1 2 3 4 5
14. 1 2 3 4 5
15. 1 2 3 4 5
16. 1 2 3 4 5
17. 1 2 3 4 5
18. 1 2 3 4 5
19. 1 2 3 4 5
20. 1 2 3 4 5
21. 1 2 3 4 5
22. 1 2 3 4 5
23. 1 2 3 4 5
24. 1 2 3 4 5
25. 1 2 3 4 5
26. 1 2 3 4 5
27. 1 2 3 4 5
28. 1 2 3 4 5
29. 1 2 3 4 5
30. 1 2 3 4 5

APPENDIX F

Strategy Report Instructions

Sometimes the particular stimulus materials used in a study have a strong effect on people's ability to follow instructions. Some stimuli make following instructions easy, while other stimuli make it almost impossible. The purpose of this study is to test the compatibility of various instructions and stimuli. The task you've just completed is just one of eight different combinations of stimuli and instructions. People in the other seven conditions might see a different kind of stimulus material than you saw, or they might be asked to think about the material differently. You've been doing your best to follow instructions. However, the form your thinking actually took as you did the task may have depended on factors beyond your control. Some thinking seems to be primarily verbal, other thinking seems to be primarily visual, and some thinking seems to be more abstract, in that it doesn't involve either specific words or specific images. None of these forms of thinking is better or more efficient than another. I'd like to know the kind of thinking that actually occurred as you performed the task you've just completed. Before you write anything on the sheet I'm going to give you, I'd like you to read all eight of the statements on it very carefully. Then decide which

statement or statements most accurately describes these thought processes. Then I'd like you to put a number on the line before each statement to indicate the percentage of the time this form of thinking occurred. The sum of the numbers will be 100%. For example, if you had the same sort of thoughts consistently, you'd put 100 on the line in front of the appropriate statement and 0 in front of the other seven statements. Or you might have thought about the material in two ways in a 50-50 ratio, or maybe a 75-25 ratio, and so forth. Just do your best to report the type of thinking that actually occurred, whatever it was. There are no right or wrong answers. Do you have any questions?

Please take as much time as you need to report your thought processes accurately. (5 MIN.) Could you use more time? ... (2 MIN) Would you please check that the percentages you put down total 100, and that your name is on the sheet. (COLLECT; DISTRIBUTE CUED-RECALL FORMS)

RECALL INSTRUCTIONS: Name on sheet; circle M or F to indicate sex; guess if uncertain; put down an answer for every item. (5 MIN) Could you use more time? ... (2 MIN; COLLECT; DISTRIBUTE RECOGNITION FORMS)

RECOGNITION INSTRUCTIONS: Name on sheet; check 20 items from initial presentation. (5-7 MIN) Count checkmarks to make sure there are exactly 20. (COLLECT)

Name _____

First, recall the sort of thinking you were doing when you were considering the two objects in each trial of the previous task.

Next, read all 8 of the statements below and decide which of them most accurately describes your approach to the task.

Then put a number from 0 to 100 before each statement to indicate the percentage of the time you used this strategy.

(The sum of these percentages should be 100%.)

---

1. _____ I visualized each of the two objects.

2. _____ I visualized the interaction between the objects.

3. _____ I thought of the names of the two objects.

4. _____ I thought of words describing the interaction.

5. _____ I visualized, and thought of the names of, each of the two objects.

6. _____ I visualized the interaction between the objects and thought of words describing it.

7. _____ I thought about each of the two objects without visualizing them or thinking of their names.

8. _____ I thought about the interaction between the objects without visualizing it or thinking of words describing it.

APPENDIX G

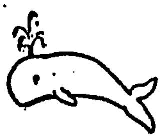
Name _____ M F (Circle one)

Please supply the other member of the pair of objects that was presented.

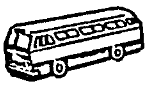
whale	_____	squirrel	_____
bus	_____	spoon	_____
lamp	_____	ambulance	_____
scissors	_____	necklace	_____
saddle	_____	hatchet	_____
goggles	_____	spider	_____
whip	_____	thermos	_____
eagle	_____	kitten	_____
fish	_____	ball	_____
dog	_____	tire	_____

Name ______________________________ M F (Circle one)

Please supply the name of the other object that was presented with each object pictured.

 ______________

 ______________

 ______________

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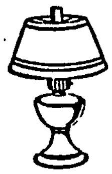
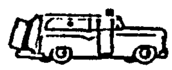
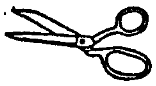
 ______________

 ______________

 ______________

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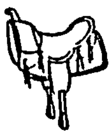
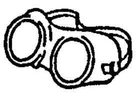
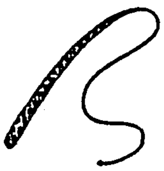
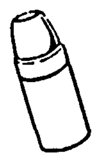
 ______________

 ______________

 ______________

 ______________

 ______________

 ______________

 ______________

 ______________

 ______________

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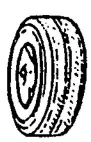
 ______________

 ______________

Name _____ M F (Circle one)

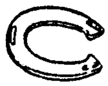
Please supply the other member of the pair of objects that was presented.

windmill	_____	hen	_____
horseshoe	_____	jacket	_____
iron	_____	cook	_____
wagon	_____	bee	_____
funnel	_____	clown	_____
thermometer	_____	baby	_____
shovel	_____	flag	_____
axe	_____	fan	_____
anchor	_____	mop	_____
badge	_____	web	_____

Name ______________________________ M F (Circle one)

Please supply the name of the other object that was presented with each object pictured.

 ____________________

 ____________________

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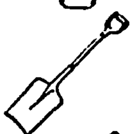
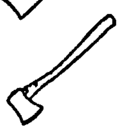
 ____________________

 ____________________

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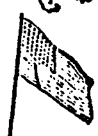 ____________________

 ____________________

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APPENDIX H

Name _____

Among the objects named below are 20 that were paired with another object during the first task. Please put a check before these 20 items only.

___ goblet	___ lightbulb	___ suitcase	___ vest
___ airplane	___ cupboard	___ propeller	___ frog
___ package	___ typewriter	___ otter	___ book
___ chair	___ wheel	___ drum	___ fence
___ piano	___ swing	___ cage	___ tracks
___ purse	___ turtle	___ porch	___ camel
___ globe	___ vase	___ mouse	___ iceberg
___ target	___ paddle	___ waffle	___ hat
___ truck	___ cookie	___ stove	___ seal
___ branch	___ crib	___ bear	___ sailboat
___ comb	___ train	___ bicycle	___ clock
___ motor	___ chimney	___ gun	___ goat
___ chart	___ canoe	___ igloo	___ sink
___ mitten	___ harp	___ scale	___ ladder
___ fishhook	___ snake	___ penguin	___ battery
___ ostrich	___ bucket	___ thumbtack	___ shoe
___ guitar	___ peacock	___ broom	___ pie
___ flowers	___ giraffe	___ tweezers	___ belt
___ stairs	___ log	___ pipe	___ banana
___ scarf	___ moose	___ tank	___ tree

APPENDIX I

THINKING ABOUT THINGS

You have participated in an experiment in cognitive psychology, an area concerned with the way people organize and use their knowledge. The study explores the effectiveness of particular ways of thinking for organizing and using particular kinds of knowledge. For example, we know that it's easier to think about an object shown in a picture if we've just seen the picture. But would seeing the picture help us to think about the object in a way that the picture did not show?

You were asked to think about pairs of objects in a particular way--by forming either sentences or visual images. You may have seen pictures of these objects or you may have seen their names, and the objects may have been presented either separately or in interaction. We want to know how these three independent variables--task, stimulus mode, and relationship presented--affected your ability to think about the objects in the way you were asked to do. We assume that this ability is reflected in your responses, relative to people in the other conditions, on our dependent variables--the "thought processes" report and the recall and recognition tasks.

A better understanding of the relative advantages and disadvantages of various strategies for organizing and

using particular kinds of knowledge would have practical importance for all of us. As members of an information-intensive society, we and our children would benefit from the application of techniques that improved our ability to acquire, to organize, and to communicate our knowledge more effectively.